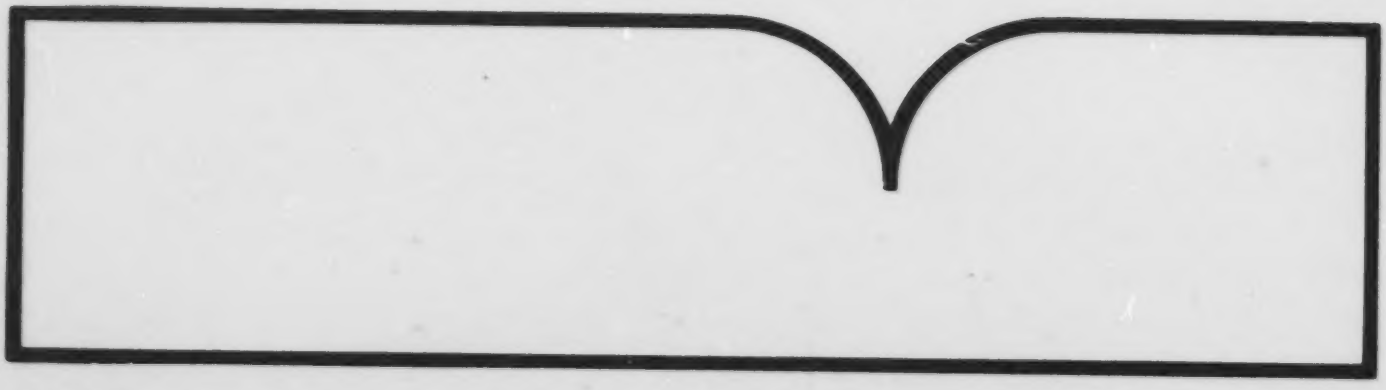
PB90-225921

Long-Range Research Agenda 1990-1994

(U.S.) Environmental Protection Agency, Washington, DC

Feb 90



U.S. Department of Commerce
National Technical Information Service
NTIS

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA/600/9-90/024	2.
3. RECIPIENT'S ACCESSION NO. PB90 225921/AS	
4. TITLE AND SUBTITLE Long-Range Research Agenda 1990-1994	5. REPORT DATE 2/90
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Richard Hardesty, Coordinator/Editor	8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS USEPA/ORD WSM Washington DC 20460	10. PROGRAM ELEMENT NO.
	11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS U.S. Environmental Protection Agency Office of Research and Development 401 M Street,SW Washington DC 20460	13. TYPE OF REPORT AND PERIOD COVERED Long Range Research 1990-1994
	14. SPONSORING AGENCY CODE EPA/600/00

15. SUPPLEMENTARY NOTES

16. ABSTRACT

The Long-Range Research Agenda is prepared in response to the Congressional requirement that the U.S. Environmental Protection Agency (EPA) submit an annual revision of a comprehensive five-year plan for environmental research, development, and demonstration after the President submits his annual budget to the Congress (P.L. 94-475, Section 5, 10/1/76; P.L. 95-155, Section 4, 11/8/87). This annual revision is required to convey the plans for no growth, moderate growth or high growth budget projections and should include an explanation of the relationship between research and existing laws which authorize environmental research, development, and demonstration. The budget projections contained therein assume a 3% increaes in the moderate growth scenario and a 6% increase in the high growth scenario. The budget projections are subject to change associated with new Agency priorities and the availability of funds.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group

18. DISTRIBUTION STATEMENT RELEASE TO PUBLIC	19. SECURITY CLASS *(This Report)* UNCLASSIFIED	21. NO. OF PAGES 129
	20. SECURITY CLASS *(This page)* UNCLASSIFIED	22. PRICE

EPA Form 2220-1 (Rev. 4-77) PREVIOUS EDITION IS OBSOLETE

PB90-225941

EPA/600/9-90/024
February 1990

Long-Range Research Agenda
1990-1994

OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, DC 20460

REPRODUCED BY
U.S. DEPARTMENT OF COMMERCE
NATIONAL TECHNICAL
INFORMATION SERVICE
SPRINGFIELD, VA 22161

NOTICE

This document has been reviewed in accordance with U.S. Environmental Protection Agency policy and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

reconsideration of the ORD program was engendered by a report titled Future Risk: Research Strategies for the 1990's. This report from the Agency's Science Advisory Board to the EPA Administrator was issued in September, 1988, and will be better reflected in the 1991 edition of this report to be published next year.

Erich Bretthauer
Acting Assistant
Administrator for Research
and Development

Contents

		Page
I.	Introduction	1
	Congressional Request	1
	ORD Mission and Obligations	1
	ORD Planning Process	2
	Plan Perspectives	3
II.	Research Committee (Legislative) Perspectives	5
	Air/Radiation	5
	Water	28
	Pesticides/Toxics	46
	Hazardous Waste/Superfund/UST	62
	Multimedia Energy	77
	Interdisciplinary	86
III.	Appendix	117
	Interagency Coordination	117
	Science Advisory Board Letter	120

Preface

The primary goal of the U.S. Environmental Protection Agency is to reduce the risks posed by pollutants to public health and welfare and to natural ecosystems. Within this context, the Office of Research and Development (ORD) has two main goals:

- To provide scientific information and data for agency decision makers to help them select cost-effective and environmentally safe means of achieving environmental results in support of the Agency's regulatory responsibilities, and
- To advance the state of knowledge on environmental problems not yet well understood.

As part of this process, the research program must anticipate and address the fundamental needs of regulatory decision making and program-specific issues. Fundamental needs include reliable estimates of the risk of adverse impact to public health and the environment associated with any policy action, reliable estimates of cost-effective risk reduction options, and reliable measurement methods for the indicators used to specify the state of the environment.

These needs drive a continuing core research program consisting of:

- Ecological risk assessment,
- Health risk assessment,
- Risk reduction, and
- Exploratory Grants and Research Centers.

The core research program is based on assumptions that our research, together with that of others, will help us better understand the fundamental mechanisms which degrade the quality of the environment. It must correctly measure the pollutants in our environment and give us an understanding of how they react in ecosystems and in individual species. It directs our

efforts towards finding early solutions, towards pollution prevention rather than end-of-the-pipe controls.

For the major area of ecological risk assessment, emphasis will be placed on:

- An intensive initial effort to define the types of ecosystems at risk and to develop measures to indicate the condition of these systems,
- Creation of a program to monitor the status of and trends in our ecosystems,
- Periodic reporting on the condition of the environment and how it is changing, and
- Long-term research to improve our understanding of how pollutants affect the structure and function of ecological resource systems.

In the human health risk assessment area, long-term research emphasis will be placed on:

- Determining, on a national basis, the exposure of humans to pollutants,
- Increasing our understanding of the mechanisms of environmentally induced noncancer health effects,
- Assessing the hazards of new environmental agents, such as bioengineered organisms, UV radiation from stratospheric ozone depletion, alternative fuels for motor vehicles, and mineral fibers used to replace asbestos,
- Investigating the human health effects of exposure to multiple chemicals,
- Developing biomarkers to estimate exposure and effects of exposure,
- Incorporating into the risk assessment process a consideration of not just whether a chemical causes an effect, but how severe that effect is, and
- Basing risk assessment on the dose delivered to the vulnerable tissues in the body, rather than on

the amount of pollutant we are exposed to before it enters the body.

In the risk reduction area, emphasis will be placed on:

- Understanding where pollutants come from in order to know how best to focus our risk reduction activities,
- Promoting the changes needed in industrial processes and products to prevent pollution,
- Educating and motivating individuals and institutions to make the changes needed to reduce risk, and
- Developing more efficient and effective technologies for controlling the pollutants that we do generate.

In the Exploratory Grants and Research Centers Program area, building on the continued strength of this nation's academic environmental research efforts, emphasis will be placed on:

- Stimulating progress in fundamental knowledge upon which the applied programs feed,
- Providing graduate and postdoctoral training for the young scientists and engineers who will become future environmental researchers and managers, and
- Increasing the probability of detecting environmental problems earlier and developing the methods to avoid or ameliorate them, thereby decreasing the costs of coping with such problems.

The research activities described in this document are based upon the planning which culminated with the President's 1990 budget proposal and reflects the research program defined by that budget. The planning process that created the 1990 program was just one phase of a larger effort that is redefining the ORD Core Research Program and from which will evolve a new perspective for ORD research in the future. This major

I. INTRODUCTION

Congressional Request

The Long-Range Research Agenda is prepared in response to the Congressional requirement that the U.S. Environmental Protection Agency (EPA) submit an annual revision of a comprehensive five-year plan for environmental research, development, and demonstration after the President submits his annual budget to the Congress (P.L. 94-475, Section 5, 10/1/76; P.L. 95-155, Section 4, 11/8/77). The annual revision is required to convey the plans for no growth, moderate growth, and high growth budget projections and should include an explanation of the relationship between research activities and existing laws which authorize environmental research, development, and demonstration. The budget projections contained herein assume a 3% increase for the moderate growth scenario and a 6% increase for the high growth scenario. The budget projections are subject to change associated with new Agency priorities and the availability of funds.

Office of Research and Development (ORD) Mission and Obligations

ORD is responsible for the development and implementation of an integrated program which supports the mission of the Agency. Its mission is to administer, in a comprehensive and balanced manner, specific federal legislation developed to control and abate adverse impacts of pollution on the human environment (Presidential Reorganization Plan #3, 1970).

In keeping with that mission, Agency management requires quality information on a timely basis for decisions relating to the assessment and management of risk from known and anticipated environmental pollution. Agency management must make decisions regarding the development of policy, guidance, standards, and

development issues of concern to the applicable program office and for recommending a media-oriented research plan.

However, for the 1990 budget the planning process was expanded beyond a short-term, media-specific focus to take into account the need for fundamental, cross-media, long-term science. This was accomplished through the development of an integrated, comprehensive planning directive by the Assistant Administrator for Research and Development, Research Program Guidance for 1990. Strategic program and policy direction was provided to research committees prior to the development of detailed plans or budget request. In addition, the document provided guidance on areas for disinvestment and enhancement by research committees and emphasized the need for cross-media, sustained research.

The FY 1990 planning process also benefited from the advice of the Science Advisory Board, particularly its report Future Risk: Research Strategies for the 1990s. The report emphasized EPA's responsibilities as a science agency and the need for ORD to balance short- and long-term research. In response to the SAB's recommendations and in recognition of the need for better strategic planning, the Agency established a Research Strategies Council, which is chaired by the Administrator and comprised of senior program and regional managers, to aid ORD in the future by overseeing its long-term planning.

Plan Perspectives

Several alternative frameworks can be used to categorize the total ORD program. Examples of the suggested perspectives for categorizing the program include legislative, regulatory program office, research discipline, source, pollutant, and effects. Since the original Congressional requirement for this report asked for an indication of the relationship of plans to existing

regulations; monitoring programs (surveillance and compliance assessment); environmental impact analyses; quality assurance and quality control; grant applications and training.

In view of the diverse products and services required from ORD to support Agency decision making (research, problem diagnosis, technical support documents, risk assessments, expert witness consultation, quality assurance management, etc.), the ORD staff must maintain an awareness of environmental research being performed by other governmental agencies (federal, state, and local), industry, academia, and the private sector. The information needs of the decision makers are critically evaluated in terms of the information available or forthcoming from all these sources. (See Appendix for a listing of interagency coordination.)

The research in EPA/ORD focuses on those areas specified in the Congressional appropriation and on subjects identified in the planning process as requiring additional information for Agency decision making.

ORD Planning Process

This year, ORD took several steps to improve its strategic planning process. The research committee structure, as described below, was supplemented by a new, strategic planning process – resulting in a more integrated, long-range research plan.

As in the past, ORD research projects and priorities were developed by Agency-wide research committees, which are structured primarily along regulatory program office lines (air/radiation, water, pesticides/toxics, hazardous waste/superfund, and interdisciplinary). Committee membership is comprised of senior-level representatives from the regulatory offices, the lead regions, and ORD laboratories. Each committee is responsible for ascertaining the priority research and

laws authorizing the Agency's environmental research, development, and demonstration work, the total program is presented primarily from the research committee perspective, which is equivalent to the regulatory office perspective. Cross media, multidisciplinary problems receiving special emphasis in the FY 1990 budget and for the foreseeable future include the following:

1. Strengthening long-term core research. This includes increasing exploratory research grants, establishing an ecological status and trends program, and an ecological research and environmental statistics program;

2. Addressing global climate change through research to gain greater understanding of the impacts the world is experiencing;

3. Improving human health risk assessment to better estimate the risks faced by people;

4. Improving assessment of human exposure to pollutants; and

5. Focusing on long-term pollution prevention and waste reduction.

A letter commenting on the review of the ORD program by the Agency Science Advisory Board (SAB) is presented in the Appendix.

II. RESEARCH COMMITTEE (LEGISLATIVE) PERSPECTIVES

Each of the media-specific research programs contains elements that are related to both the core research program and to direct regulatory program research support. The media-specific issues and associated research planned to resolve these issues are described in the following paragraphs.

Air/Radiation

1989 Revised Current Estimate: $ 72.7 million
1990 President's Budget: $ 88.4 million

Projections ($ in millions)

Growth	FY 1991	FY 1992	FY 1993	FY 1994
None	88.4	88.4	88.4	88.4
Moderate	91.1	93.8	96.6	99.5
High	93.7	99.3	105.3	111.6

Under the Clean Air Act (CAA), EPA is responsible for setting ambient air quality standards for air pollutants emitted from both stationary and mobile sources. National Ambient Air Quality Standards (NAAQS) have been set for six criteria pollutants: ozone (O_3), carbon monoxide (CO), particulate matter (PM), sulfur oxides (SO_x), nitrogen oxides (NO_x), and lead (Pb). These standards must be reviewed every five years and revised if appropriate. Compliance with these standards is the responsibility of each state through the development and implementation of State Implementation Plans (SIPs), which limit emissions from sources, set time tables for compliance, and establish monitoring procedures.

The Agency is also responsible for setting technology-based New Source Performance Standards (NSPS) to

limit air pollutant emissions from new sources or from existing sources that have been modified. In areas where the air quality is better than that required to meet primary and secondary standards, emissions from new or modified sources are restricted under the Prevention of Significant Deterioration (PSD) program.

EPA is also responsible for limiting emissions of air pollutants that are hazardous to human health but are not already regulated as criteria pollutants. Included are volatile organic carbons (VOCs), which are ozone precursors. In addition, Title IV of the Superfund Amendments and Reauthorization Act of 1986 (SARA) authorizes research and other technical activities on indoor air and radon.

ORD provides the scientific data bases, methods, models, assessments, emission reduction technologies, and corresponding quality assurance support to implement these legislative authorities. Within the scope of the air research program, seven major issues have been identified that cut across scientific disciplines and the pollutant-specific structure of the research program. In addition, EPA conducts a radiation monitoring and quality assurance program.

EPA has identified several topics in the air research program that will require special attention in the coming years. Among these are support for the ozone attainment program, stratospheric ozone depletion, global climate change, acid aerosols, and the problems of unregulated pollutants in urban air. These issues will be emphasized during the next five years of air pollution research.

Major Research Issues

Criteria Pollutants

What scientific support is necessary to develop and review primary and secondary NAAQS?

Scientific Assessment: The review and revision of NAAQS is a continuing effort, based upon new and evolving scientific information. ORD contributes to this function by publishing new or revised Air Quality Criteria Documents (AQCDs), which are then used by regulators to revise NAAQS. In the immediate future, revision of the criteria documents for CO and NO_x will continue, and an addendum to the PM/SO_x criteria document will be completed. For all of the criteria pollutants, a continuing technical evaluation and assessment effort is maintained. A major assessment of acid aerosols will be undertaken, using new ORD research findings. This assessment document will be used for determining whether to list acid aerosols as a criteria pollutant. Technical evaluations are being conducted for use by the regulatory office in evaluating the NAAQS for lead, SO_x, O_3, and PM and for determining whether to list acid aerosols as a criteria pollutant.

Health Effects: For each of the criteria air pollutants and for acid aerosols, many of the sensitive population groups and the pollutant exposure ranges of interest have generally been identified. However, health effects testing of these pollutants must continue in both animal and human subjects to ascertain dose-response relationships. The health endpoints of concern are mainly respiratory, metabolic, and immune system effects of O_3, NO_2, SO_2, and PM and the cardiovascular and neurologic effects of CO. Extensive research is being undertaken on acid aerosols to provide information for a major risk assessment and consideration whether to list acid aerosols as a criteria pollutant.

Research on the health effects of very short exposure to high levels of particles and SO_2 will support reevaluation of emergency level standards, particularly as they apply to sources that emit occasional bursts of pollutants for extremely short periods of time.

Emphasis will also be placed on evaluating the effects of long-term, low-level versus short-term, higher

peak exposures to oxidants, particularly NO_2, and the effects of both long-term and short-term exposures to the coarse fraction of airborne particles smaller than 10 microns in diameter. The information obtained from this research will be factored into the next round of criteria documents and used in the review of NAAQS.

To improve our ability to relate animal data to actual human consequences and to develop more reliable risk estimates of exposure to air pollutants, techniques will be developed to extrapolate from animal to human effects, from high to low doses, and from acute to chronic effects. To do this, information in three critical areas will be considered: dosimetry–the amount of pollutant which reaches specific target sites in the body after exposure to a given concentration of pollutant; species sensitivity–the potential variations in response of different animal species to the same dose of pollutant; and dose/response.

Human volunteers are being exposed to criteria pollutants for brief periods of time at concentrations similar to those encountered in daily life, in order to measure the resulting effects on heart and lung function, immune response, and other physiological and biological parameters. Similar studies are being conducted with animals. Animals are also being exposed chronically to these pollutants, and the cumulative lifetime effect of these exposures will be determined. These dose-response data, combined with dosimetry and species-sensitivity information, provide the information necessary to infer the effects that chronic exposure to a given pollutant may have on humans. To support the human inhalation studies, additional resources have been provided to equip the new Clinical Research Facility located in Chapel Hill, NC.

Epidemiological research provides the most direct evidence of human health effects from environmental exposures to pollutants. Epidemiological studies are

being done to ascertain the health effects of total exposures (indoor and outdoor) to the criteria air pollutants.

Welfare Effects: To assess the need for secondary air quality standards for criteria pollutants, research is needed on the impact of air pollution on vegetation and visibility degradation. Recent research has been completed on the effect of O_3 on crops that indicates that fluctuations of O_3 levels in conjunction with other conditions may seriously affect crop plant response. While crop model research will be reduced, increased effort will be invested in a research program to determine the damage done by ozone. For regulatory purposes, EPA needs to quantify O_3 effects on forests to determine what types of forests are affected and to establish their relative sensitivity; to define dose-response relationships that allow estimates of benefits from reduced O_3 exposure; and to translate the data into air quality standards. The experimental approach will closely follow that taken with crops, but perennial trees will be utilized rather than annual plants.

Atmospheric Processes: Research will be conducted to determine the extent of visibility impairment. Specifically, the role of aerosols on visibility reduction will be assessed; visibility trends for the U.S. will be determined using available data bases; and measurement and monitoring techniques will be developed to characterize more completely the extent of visibility changes. A regional visibility research network will provide data for analyzing source-receptor relationships, and models will be developed to assess visibility protection strategies. Research is also needed to assess the influence of particle size and composition on soiling and to aid in the development of a risk assessment. Research on the characterization, potential for neutralization, and modeling of the behavior of acid aerosols will also be emphasized.

Monitoring: New and improved monitoring methods are needed to identify areas where public health and

welfare are threatened and to establish air quality trends. In addition, accurate, reliable monitoring methods are necessary to determine compliance with standards and to evaluate the need for enforcement actions. This will be carried out through the testing, evaluation, improvement, and standardization of methodologies and systems for measuring ambient pollutants. Research will focus on acid aerosols to provide monitoring and exposure information to support the planned risk assessment.

Quality assurance is required to provide a reliable estimate of the precision and accuracy of the data obtained from measurements from sources such as the State and Local Air Monitoring Networks. This is carried out through the use of audits of the laboratories and from the use of standard reference materials that have been prepared, verified, and distributed to the user laboratories.

New Source Performance Standards (NSPS) and State Implementation Plans (SIPs)

What scientific support is needed to develop NSPS and SIPs?

Control Technology: Research will be conducted to characterize emission sources and evaluate and improve the cost-effectiveness of emission reduction technologies, thereby reducing the cost of complying with SIPs.

Improved control technology is also needed for sulfur and nitrogen oxides. For SO_x, further research will be conducted on conventional spray drying for utility and industrial boilers. Also, comparative assessments are needed for various absorbents to reduce the cost of spray drying flue gas desulfurization (FGD). The role of dry injection techniques in FGD systems will also be investigated. Research to control NO_x will focus on evaluating the applicability of combustion modification techniques to industries. Needed research on reburn-

ing and changes in precombuster burner designs will continue.

Research to control particles focuses on improving the performance, reliability, and cost-effectiveness of the multi-stage electrostatic precipitators (ESPs) and fabric filtration. The major purpose of this research is to improve collection of small particles that have become increasingly important in meeting particle standards. ESPs may assist in acid rain mitigation when used with dry add-on SO_2 removal processes. Precipitators are also appropriate when facilities switch to low-sulfur coals, with their more difficult-to-collect fly ashes. Another particle control measure that shows promise is electrostatically augmented fabric filtration (EAFF). Also, recent research indicates that proper conditioning of the particulate matter can reduce pressure drop significantly, resulting in fabric filters one-third the size of conventional units. Additional research to verify this finding is necessary and has begun.

Atmospheric Processes: Pollutants emitted into the air often undergo chemical reactions that change them into different compounds. Models to predict this phenomenon are being developed on the urban and regional scale. These models will provide information necessary to develop, evaluate, and implement cost-effective air pollution control strategies for SIPs and PSD determinations.

Over the last few years, a variety of air quality models have been developed; however, evaluations of these models indicate that the accuracy and reliability of their predictions need to be increased. In order to improve urban scale models, smog-chamber studies will be conducted to obtain a better understanding of the atmospheric chemical processes associated with the formation of oxidants and inhalable particulate matter. Emphasis will be placed on the impact of lower hydrocarbon/NO_x ratios and the role of specific categories of

VOCs such as aromatic hydrocarbons and aldehydes in producing atmospheric ozone and other oxidants. Source apportionment modeling techniques will be developed and evaluated for both nonvolatile and volatile organics.

The Regional Oxidant Model (ROM), which has been developed to test and evaluate control strategies for ozone abatement in the northeastern United States, will be expanded for application to other regions of the U.S., such as the Southeast. In order to expand the ROM to other areas, regional differences in hydrocarbon emissions, meteorology, and geography must be analyzed. The ROM will be upgraded in terms of its ability to predict both atmospheric transport and chemistry of ozone pollution.

In order to make dispersion and mathematical models available to the regulatory and research community, the Air Pollutants in Microenvironments, formerly known as the User Network for Applied Modeling of Air Pollution (UNAMAP) will be updated to include state-of-the-art models. Air pollutants will be studied to stimulate and develop applied models of sources, methods of transport, fate, flow characterization, and dispersion.

On the regional scale (up to 1,000 km), laboratory and field studies will be conducted to improve the ability of models to predict the atmospheric transport, transformation, and deposition processes for air pollutants such as ozone and particulate matter. Alternative mathematical techniques and new meteorological tracers will also be evaluated to determine their ability to improve modeling predictions. The regional scale models will be adapted to predict both episodic (hours, days) and longer (months, seasons) time periods.

Monitoring: Research will be conducted to improve standardized methods for monitoring stationary sources. In order to increase the precision and accuracy of these monitoring systems, audits and quality assurance assis-

tance will be carried out for state, local, or federal laboratories involved in measuring NO_x, organic precursors, SO_2, sulfate, particulates, or lead. Necessary reference materials and guideline documents will be provided to implement the requirements of the CAA. Quality control standards will also be prepared, verified, and distributed to these laboratories.

Remote monitoring systems are being developed, evaluated, and applied for use in areas where data are needed for SIP evaluation or revision and for Agency evaluation of the need for new standards.

Hazardous Air Pollutants (HAPs)

What scientific support is needed for regulatory decisions about potentially hazardous air pollutants?

Monitoring: Few monitoring methods are available for measuring concentrations of and human exposure to potentially hazardous air pollutants, especially organic compounds; therefore, new sampling and analytical systems and a set of validated source-sampling methods will be developed for important sources of hazardous air pollutants that currently cannot be monitored with adequate precision and accuracy. Research to develop methods of monitoring ambient hazardous air pollutant concentrations will be accelerated, as will work on passive monitors and new sorbents. This will extend the measurement capability to chemicals not collected by current methods and to new monitoring situations such as exposures near hazardous waste sites. The Toxic Air Monitoring System (TAMS) will continue to characterize select urban atmospheres and determine the magnitude and extent of the hazardous air pollution problem. In addition, TAMS will support the "urban soup" program, which is a multidisciplinary effort to characterize and assess risks from a complex mixture of pollutants in urban areas.

Health Effects: In general, the strategy for investigating the health effects of toxic air pollutants must be quite

different from that employed in the study of criteria pollutants. First, because of the potential hazards of these pollutants, clinical studies of exposed human volunteers cannot be conducted; however, epidemiological studies of exposed populations may be feasible, and lung washings from nonexposed volunteers can be made in the clinical setting and the harvested cells exposed in vitro to various chemicals. Because direct animal-to-man extrapolation is difficult, it is necessary to develop animal models that use biological indicators of neurotoxic, respiratory, genetic, reproductive, or developmental effects in order to predict effects in humans. Research to develop such models will be undertaken during the next five years. Inhalation exposure chambers are being used to study pulmonary, developmental, neurotoxic, and other effects of priority air pollutants on animals.

Control Technology: The highest priority for research in this area is to assess technologies for their ability to reduce toxic emissions from various industrial and combustion sources. These include both gaseous and particulate species. A near-term goal is to control emissions from wood-burning stoves, beginning with evaluations of the efficiency and longevity of wood stove catalysts.

As part of the long-term strategy to control HAPs, industries that are deemed to be high-priority sources of HAPs will be identified. Such industries include petroleum refineries, organic chemical manufacturers, and iron and steel mills. Research will be performed to develop efficient and effective control strategies for such high-priority emitters.

Because much is already known about other criteria pollutants, priorities for research in control technology have shifted to VOCs, to assist in meeting ozone level attainment goals. VOCs, which react with NO_x and sunlight to produce ozone, are a major cause of the ozone nonattainment problem. Although emissions

from major stationary sources are being reduced, small sources, such as dry cleaners, gas stations, and paint users, are not being widely controlled. Although these sources individually emit small amounts of pollutants, collectively they may constitute a significant problem. Control technologies such as industrial flares, carbon adsorption, catalytic oxidation, thermal incineration, and other advanced technologies, as applicable, will be assessed to determine their performance and cost in reducing VOC emissions from such sources. Emphasis will be placed on developing and evaluating methods to control VOCs without resorting to costly add-on control devices.

A Control Technology Center (CTC) was established in 1987 to provide support to state and local agencies with information on controlling air toxics, VOCs, and related pollutants. The types of services provided by the CTC include telephone hotline calls, direct engineering assistance projects, and technical guidance projects. The CTC is a successful program that has shown significant growth since its formation. The number of requests for assistance received from state and local agencies continues to grow.

Atmospheric Processes: Consideration of the formation, atmospheric stability, and removal of HAPs is essential in assessing exposure and risk. Of particular concern is the formation in the atmosphere of toxic pollutants from chemical reactions among individually innocuous compounds. On a schedule consistent with the Agency's regulatory calendar, laboratory and field studies will be performed to determine the reaction rates, products, and natural variabilities of HAPs under review. Chemistry will be studied in isolated laboratory systems to obtain accurate data on kinetics and mechanics. HAPs will also be investigated in photochemical smog chambers, which provide a better basis for extrapolation to the atmosphere. New studies will be

undertaken to determine the extent to which HAPs are formed in the atmosphere from innocuous compounds.

Integrated Air Cancer Program: There is a great deal of uncertainty regarding the relationship between air pollution and human cancer. Determining the extent to which air pollution is responsible for or related to human cancers could have a major impact on EPA's regulatory program. Thus, a long-term, interdisciplinary research program has been developed to address the major scientific questions regarding the relationship between air pollution and the development of human cancer.

The three basic goals of this program are to identify the principal airborne carcinogens, to determine which emission sources are major contributors of carcinogens to ambient air and which chemicals are carcinogen precursors, and to improve the estimate of exposure and comparative human cancer risk from specific air pollutant emission sources. Field tests of relatively isolated single-source categories are essential for developing methods to evaluate the more typical multiple-source environments to which the general population is exposed. A current study focuses on quantifying carcinogens emitted from residential wood-fired combustion systems, residential oil combustion, and motor vehicles. The results of this study will be immediately useful, particularly as surrogates for similar environments, while the study design can be adapted for use in more complex environments.

In the monitoring and modeling component of the project, samples of ambient air in the "breathing zone" of persons in an urban/industrial area and a suburban area are being collected and analyzed for carcinogens and mutagens. Comparisons between the ambient and personal samples and between the urban and suburban concentrations will be made, and relationships between exposure and dose will be studied. The relative importance and contribution of gaseous and volatile organic compounds and of semivolatile and particulate organic

compounds to total airborne carcinogens will be determined. In addition, laboratory studies will be conducted to determine the atmospheric formation and fate of bioactive compounds.

Health research focuses on methods development and data gathering to evaluate the human cancer risk from individual and, ultimately, complex source emissions. A comparative methodology to predict risk will be adapted to evaluate and utilize short-term mutagenesis and animal carcinogenesis data on emissions. Research to identify the major sources of hazardous air pollutants and to characterize these emissions from various combustion sources of primary concern will serve as the basis of the engineering component of the project.

Scientific Assessment: A three-tiered process is employed in assessing scientific data bases for substances considered to be HAP listing/regulation candidates. Tier I reports are an initial review of literature on health effects associated with a given chemical or class of chemical substances. If no adverse health effects are found likely to be associated with exposures, and the Office of Air and Radiation (OAR) decides not to list the substance as an HAP, then the Tier I report is published. However, if significant effects appear likely, then a draft Health Assessment Document (HAD) is prepared for review by a scientific workshop (Tier II). The final tier (Tier III) would include public review and comment, SAB review, and publication of the HAD. Beginning in 1990, this assessment process will look at source categories. Examples of possible source categories that might be examined include hospital incinerators, creosote production facilities, glass manufacturing, and styrene production facilities.

In addition to the preparation of health risk assessments, increased emphasis will be placed on providing technical information and assistance to the regions and states on issues related to air toxics. A new Air Risk Information Support Center (RISC) hotline has been

established to provide the regions, states, and the public with health risk information on air toxics.

Mobile Sources

What scientific support is needed to develop mobile source regulations?

Atmospheric Research: As the driving fleet ages and changes occur in engine design, models to assess the impacts of mobile source emissions on ambient air quality need to be refined, and studies must be conducted to evaluate the impact of new emissions. Greater emphasis will be placed on evaluating alternative fuels, including methanol, ethanol, and natural gas. The two primary pollutants of importance from methanol-fueled vehicles are methanol and formaldehyde. Analytical procedures to measure methanol and formaldehyde will be developed and emission characterizations performed. Research to determine the photochemistry of emissions from methanol-fueled vehicles will also be conducted. Emissions from future gasoline-fueled vehicles and diesel-fueled vehicles equipped with advanced control technologies will be characterized. Also, evaporative emissions from motor vehicles will be characterized under a number of simulated driving and weather conditions.

Monitoring: Improved exposure-activity pattern models will be developed from exposure data from past field studies. Further refinements of the Simulation of Human Activities and Pollutant Exposures (SHAPE) model will be conducted, and the basic modeling approach will be adapted to additional mobile source air pollutants. Validation of the SHAPE model and other exposure models will continue using existing human exposure data bases. Such tools are required for making adequate estimates of risks from mobile source air pollutants.

Health Effects: Studies of the cardiovascular and neurotoxic effects of CO will continue. A new research effort on the health effects of alternative fuels and fuel additives will begin. The Health Effects Institute is expected to continue its program on CO, NO_2, O_3, diesel exhaust, and aldehyde research. New emphasis will be placed on studies to support risk assessment for diesel exhaust and on the development of newly identified mechanisms of health effects.

Stratospheric Ozone Depletion

What scientific data are needed to determine and mitigate the impact of stratospheric ozone depletion on public health and the environment?

By preventing most harmful ultraviolet (UV-B) radiation from reaching the earth's surface, the stratospheric ozone layer serves as an important shield protecting human health and welfare. It is accepted that chlorofluorocarbons (CFCs) currently are causing a depletion of stratospheric ozone. Several serious consequences are possible, including (1) increases in melanoma and other skin cancers, (2) suppression of the human immune system, (3) decreased productivity of commercial crops and marine fisheries, (4) increased production of ground-level ozone and acid aerosols, and (5) accelerated degradation of polymeric materials.

The signing of the "Montreal Protocol on Substances that Deplete the Ozone Layer" on September 16, 1987, set deadlines for decisions on tightening existing controls on ozone depletion. ORD is pursuing research to meet the needs of Agency policy makers under the Montreal Protocol. Even under the terms of the Montreal Protocol, the volume of CFCs in the atmosphere is expected to increase into the early twenty-first century. Research is required to determine the potential mitigation strategies for anticipated UV-B effects on human health and welfare.

Research is planned to (1) analyze predictive models in light of new atmospheric and ground-level UV-B monitoring data; (2) determine potential health effects, particularly the contribution of increased UV-B radiation to the suppression of the immune response, and the increase in the incidence and severity of infectious diseases; (3) determine the effects of UV-B radiation on marine ecosystems and fisheries; and (4) determine the effects of UV-B radiation on wetlands systems. Of particular interest is research on the impact of UV-B radiation in two areas: ecosystems directly related to the world's food supply and human health. Finally, a major priority will be given to research planned to investigate engineering and technological aspects of the man-made gases that contribute to the thinning of the ozone layer and technological alternatives to CFCs and Halon.

Global Climate Change

What research is needed to determine the causes and impact of global climate changes?

Increased atmospheric concentrations of carbon dioxide (CO_2) and other gases (CH_4, N_2O, NO_x, VOCs, CO, and CFCs) have raised concerns in both the general public and the scientific community about potential climate change. Much uncertainty exists about how climate change may impact specific geographic regions or ecological systems. Research will be initiated to determine the likelihood and magnitude of climate change, the relative contribution of man-made and natural sources of the implicated trace gases, the atmospheric/chemical processes in which these gases participate, and the extent of the ecological effects resulting from climate change.

Research to link the following four areas will be initiated: anthropogenically created changes in emissions of radiatively important trace gases, changes in atmospheric chemistry, changes in climate, and the impacts

of resultant climatic and chemical environment on human society.

To provide policy makers with reliable projections on the potential for global warming and its environmental consequences, the research program has been expanded substantially. Future research will focus on regional-scale effects including the impact of climate change on key ecosystems (such as boreal forests). The proposed research has been coordinated with other federal agencies such as the National Aeronautics and Space Administration (NASA), National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Agriculture (USDA), U.S. Geological Survey (USGS), U.S. Department of the Interior (DOI), and U.S. Department of Energy (DOE). It will emphasize estimating potential changes in such major resources as forested ecosystems and surface water. Also, emissions research will develop data for source/sink relationships for a variety of radiative trace gases and evaluate potential emission management techniques. Atmospheric modeling will expand to include estimates of global consequences of tropospheric air-quality changes. Ecological and environmental effects will be evaluated in important unmanaged systems (forest, surface freshwater, and coastal and estuarine ecosystems). Effects of climate change and seasonal water availability on agro ecosytems will be examined, and an evaluation of potential control technologies for trace gases, especially nitrous oxide and methane, will be made. Possible climatic conditions resulting from global warming will be developed for a wide variety of regional situations. Research will also be initiated on the effects of global warming on tropical vegetation and biodiversity, the possible consequences of reforestation strategies on total carbon and nitrogen levels, and analysis of global monitoring data for trace gases.

In addition, there has been much interest in the link between CFCs and possible climate change effects

brought about by the increase in carbon dioxide and other trace gases and the "greenhouse effect." CFCs are greenhouse gases and account for about one-fifth of the current warming potential. Although regulation of CFC production and consumption will help reduce the greenhouse effect, regulatory reduction of the atmospheric loading of the greenhouse gases, carbon dioxide, and nitrous oxide may have an effect on stratospheric ozone.

Indoor Air

What scientific support is needed for regulatory decisions about indoor air pollution?

In recent years, as public and Congressional interest in indoor air quality began to surface, EPA and other federal agencies were directed to begin exploring the dimensions of the potential indoor air quality problem. In October 1986, Title IV of SARA mandated that EPA conduct an indoor air research program. Subsequently, ORD formulated the framework around which the current research program is structured.

The ORD Indoor Air research program emphasizes four major research areas: source characterization and mitigation, monitoring, health effects, and exposure assessment and risk characterization.

Source Characterization and Mitigation: Emphasis will be placed on conducting chamber studies of emissions, building on recent procedures developed by the program; testing air cleaners; and developing models to compare the effectiveness of ventilation, source modification, and air cleaning strategies. Guidance will also be provided to the Consumer Product Safety Commission (CPSC) for the selection and operation of kerosene heaters.

Monitoring: The monitoring program will focus on the development of low cost monitoring devices for indoor air pollutant concentration measurement and on

developing state-of-the-art interagency research devoted to characterizing "sick buildings."

Health Effects: Under the Health Effects heading, the program will initiate studies to better understand human neurobehavioral responses to mixtures of VOCs and to assess genotoxicity of emissions from kerosene heaters.

Exposure Assessment and Risk Characterization: Exposure assessment and risk assessment associated with indoor air pollution is complicated by the diversity of exposure settings and the large number of possible combinations of indoor air pollutants that could be encountered. This component of the indoor air research program will focus on evaluating different approaches to assessing indoor pollutant exposures and on identifying qualitative hazards associated with indoor pollutants.

Other Research Activities

NHANES-III: EPA is participating in an interagency consortium that will conduct the next National Health and Nutrition Examination Survey (NHANES-III). EPA's chief goal in this endeavor is to obtain national baseline data on several biological indicators of exposure and on a variety of health outcomes, some of which may be associated with those exposures. This information will be used to generate hypotheses about relationships of exposure to effect.

Health Effects Institute: Research at the Health Effects Institute (HEI) will focus on human dose response characterization and the quantification of human risk from mobile source pollutants with increased attention on major uncertainties concerning unregulated automotive pollutants.

Radiation Research

What technical support is necessary to ensure that the public is adequately protected from exposure to radioactive materials in the environment?

Monitoring: On a continuing basis, EPA supplies comprehensive radiological monitoring and surveillance services to the Department of Energy (DOE) to meet that Agency's nuclear test monitoring requirements, especially at the Nevada Test Site. Other locations at which such support is regularly provided include Mississippi, Colorado, and New Mexico. Advanced monitoring systems are employed, primarily offsite, to measure the amount of radiation escaping the site following test blasts. A report is generated yearly that details the locations monitored and test results. This work is expected to continue at the same level of effort during the next five years.

EPA conducts a radiochemical analytical quality assurance program that supports federal, regional, state, and local laboratories that measure radioactivity to assess the impact of local nuclear facilities. The purpose of this program is to ensure that scientifically credible data, methodologies, and assessments are used when determining public exposure to radioactive materials. Each year, EPA reports on laboratory radionuclide studies conducted during the previous year. This is a continuing effort and is expected to remain at its current level.

Radon: In support of EPA's Radon Action Plan and pursuant to Toxic Substance Control Act (TSCA) Title III "Indoor Radon Abatement," ORD will continue developing and demonstrating cost-effective methods of mitigating and preventing the entry of radon into homes and other structures. A new focus on post-mitigation analysis and on radon in schools will be pursued beginning in 1990. Publications directed to states, builders, homeowners, and businesses on protecting against ele-

vated indoor radon levels will be produced and updated, based on the results obtained from additional field demonstrations and other newly available information.

Summary of Long-Term Trends

During the past 15 years, much progress has been made in cleaning up the nation's air. Increased use of lead-free gasoline has sharply decreased ambient lead levels, and the recent move to speed up the lead phase-down program promises to cut these levels even further. Urban areas are experiencing fewer severe pollution episodes. Catalytic converter use has greatly diminished carbon monoxide and hydrocarbon emissions from automobiles. Reflecting these trends, the air research program has begun to focus on a number of new questions: understanding the health hazards posed by unregulated toxic pollutants, by acid aerosols, by complex mixtures of urban air pollutants, and by the long-term exposure to low levels of criteria pollutants; gaining a better understanding of the effects that man-made pollution is having on the atmosphere and on the Earth's climate.

Within the area of toxic air pollution research, EPA will focus on several objectives. Monitoring methods will be improved, and attempts will be made to characterize urban atmospheres and determine national pollution trends. Efforts will be made to identify the most toxic pollutants and multiple-pollutant sources and to determine their health effects. The formation, transport, and fate of HAPs will also be investigated. The Integrated Air Cancer Program (IACP) will be continued, drawing on the resources of several EPA laboratories to discover the extent to which toxic pollutants contribute to this country's cancer rates. The health effects of pollutants associated with the burning of municipal wastes and with new motor vehicle fuels will be studied. Research on control technology for municipal waste incineration will be performed.

With the cooperation of other federal agencies interested in the hazards of indoor air pollution, EPA will be applying modern methods to monitor indoor exposures to radon, VOCs, NO_2, particulate matter, and other contaminants. Indoor emissions will be characterized and exposure models will be constructed to predict indoor exposures to specified pollutants. Ultimately, this information will be of use in determining the total exposure–indoor and outdoor–that humans receive to these pollutants.

Within the criteria pollutant program, an important new ecological issue is the need to determine the extent to which ozone is responsible for low growth rates, susceptibility to disease, and other damage to forests. Additional remaining concerns include ozone nonattainment and human health effects of exposures to NO_2 and particulate matter. Ozone control research will focus on small stationary sources of VOCs, such as dry cleaners and gas stations, to develop applicable, low-cost methods of cutting VOC emissions. Health research on NO_2 will concentrate on clinical, epidemiological, and toxicological evaluations of exposure, particularly in susceptible populations, such as children and persons with impaired respiratory systems.

Acid aerosol research will include the development of new monitoring methods that can be used to acquire exposure data. Further work will be done to enhance our understanding of the nature and character of these aerosols. The potential for neutralization of atmospheric acid aerosols will be investigated with special emphasis on the extent to which oil films inhibit the neutralization. Finally, current air pollution models must be modified to deal with the special problems posed by modeling atmospheric behavior of aerosols.

The recent Montreal Protocol focused international attention on the problem of stratospheric ozone depletion. In order to meet the Protocol's 1994 deadline, ORD is initiating a major research effort on the effects

of ozone depletion and the resulting increases in UV-B radiation on human health and the environment.

The potential impact of global climate change could pose the largest and most significant long-term man-made environmental problem of the future. To provide policy makers with reliable projections on the potential for global warming and its environmental consequences, the current research program will be expanded substantially. Future research will focus on regional-scale effects including the impact of climate change on key ecosystems (such as boreal forests). The proposed research, which has been coordinated with other federal agencies such as NASA, NOAA, USDA, USGS, DOI, and DOE, will emphasize estimating potential changes in such major resources as forested ecosystems and surface water. Also, emissions research will develop data for source/sink relationships for a variety of radiative trace gases and evaluate potential emission management techniques. Atmospheric modeling will expand to include estimates of global consequences of tropospheric air quality changes. Possible climatic conditions resulting from global warming will be developed for a wide variety of regional situations. Finally, research will be initiated on the effects of global warming on tropical vegetation and biodiversity, the possible consequences of reforestation strategies on total carbon and nitrogen levels, and analysis of global monitoring data for trace gases.

Water

1989 Current Estimate: $ 45.7 million
1990 President's Budget: $ 49.6 million

Projections ($ in millions)

Growth	FY 1991	FY 1992	FY 1993	FY 1994
None	49.6	49.6	49.6	49.6
Moderate	51.0	52.6	54.2	55.8
High	52.5	55.7	59.0	62.6

EPA's water research program provides the technical and scientific support necessary to implement the Agency's regulatory responsibilities under the Clean Water Act (CWA), the Safe Drinking Water Act, the Marine Protection, Research and Sanctuaries Act, and a number of Executive Orders and omnibus statutes. Research on water issues is conducted by the ORD laboratories and by universities and private research institutions supported in part by EPA grants and cooperative agreements. EPA's water research is important to the development of both drinking water and water quality regulations. The program is heavily involved in the evaluation of innovative and cost-effective treatment technologies and the provision of technical assistance to municipalities, industry, and private landowners. In addition, increasing emphasis is being given to research on the environmental impacts of pollution upon aquatic biota and their ecosystems.

The water research program will continue to provide support in the following areas: developing new and revised drinking water Maximum Contaminant Levels and Health Advisories; developing Criteria Documents and the scientific underpinnings of ambient water quality regulatory policies; assisting the regions and states in meeting the growing demand for toxicity-based

National Pollutant Discharge Elimination System (NPDES) permits; providing standardized monitoring methodology, quality assurance guidance, calibration reference materials, and performance audits to assess and maintain an acceptable level of self-compliance monitoring data quality; developing assessment techniques for coastal and estuarine waters; providing technical support to the municipal wastewater construction program in pretreatment, sludge, operation inflow, technology evaluation, and other areas; improving analytical and prediction technology for assessing ground-water contamination; developing cost-effective methods for cleaning up contaminated ground water; providing support for states in developing wellhead protection programs; and supporting the underground injection control regulatory program.

The six research areas described in this report–Water Quality Based Approach; Marine, Estuarine, and Great Lakes; Wastewater Treatment Technology; Drinking Water Technology; Drinking Water Health; and Ground Water–represent the principal concerns in the water research area and correspond both to the organizational structure of the Water Research Committee and the Agency's water research budget.

Major Research Issues

Water Quality Based Approach Permitting

What information and methods are needed to support a water quality-based approach to pollution control?

The CWA recognizes two types of regulatory requirements needed to restore and maintain the quality of the nation's waters: (1) technology-based requirements for all direct dischargers. These are set on a case-by-case basis. However, the Agency also promulgates guidelines to set uniform national requirements for direct dischargers by industry category; and (2) water quality-based standards to define the uses to be

made of water, such as drinking water supply or recreation, and subsequently establish criteria protective of that use. Despite significant reductions in point-source pollutant levels as a result of the implementation of technology-based discharge limits, some water bodies still do not meet water quality standards. Moreover, increasingly important water quality problems are caused by toxic substances, diffuse (non-point) sources, and reduced flow.

Ecological Hazard Assessment for Water Quality: This research will develop and evaluate regional approaches for establishing water quality standards and conducting water quality assessments. The regional integrative assessment approach, which includes the development and evaluation of an index of biological integrity for streams, and experimental designs for estimating the status of aquatic resources based on population, will be developed and refined. Water quality criteria will be evaluated to determine which chemicals pose the greatest threat to wildlife through the aquatic food chain. Ecological criteria will be developed by integrating terrestrial and aquatic characteristics into an assessment protocol.

Sediment Quality Criteria: Research will assist the Office of Water in developing sediment quality criteria which can be used to establish site-specific criteria and form the basis for state sediment quality standards.

Waste Load Allocation: Environmental processes characterizations will increase available data bases, and waste load allocation models will be developed, improved, simplified, and tested to implement the water quality based approach. The Center for Exposure Assessment Modeling in Athens, Georgia, will catalogue, maintain, and provide models, user manuals, and associated training and technical assistance to EPA regions and states.

Monitoring and Quality Assurance: EPA will continue to identify, evaluate, standardize, and validate analytical procedures for characterization/monitoring of waterborne pollutants. Emphasis will be given to establishing protocols that screen water quality through biochemical and/or biological testing. In the area of chemical methods development, generic instrumentation approaches to monitoring, in addition to a chemical-by-chemical approach, will be evaluated. Contamination of the water column, underlying sediment, or introduced sludge will be individually addressed in an attempt to maximize the economy of each class of measurement. Performance of laboratories and measurement methods will continue to be assessed, and corrective action will be taken to help maintain the quality of the Agency's data base supporting critical decision making.

Water Quality Criteria - Aquatic Life: Toxicity testing methods for aquatic life will be developed, validated, and provided to regions and states for predicting in-stream water and biological impacts in fresh and brackish water and marine systems. Research will continue to support the integration of pollutant-specific controls with whole-effluent-toxicity testing procedures and Best Available Technology. The significance of toxicity and persistence factors to biota will be determined and methods developed for integration into the permitting process. Field tests will compare site-specific criteria modification techniques with the whole-effluent-toxicity approach. Freshwater and marine water quality criteria and advisories for protection of aquatic life based on specific chemicals will be developed as needed.

Water Quality Criteria - Scientific Assessment: The scientific assessment program will provide guidance documents for assessing the risk of human exposure

to chemical pollutants and will evaluate site-specific health hazards, as required, by states and EPA.

Wetlands in Water Quality Protection: The wetlands research effort will establish a scientifically valid framework for assessing the cumulative impact of changes so that wetland programs can more effectively protect important environmental functions. This research will also assess the effectiveness of wetlands mitigation and determine the role of wetlands in water quality protection.

In other areas, guidance for assessing the risk of human exposure to chemical pollutants and the evaluation of site-specific health hazards will continue under the scientific assessment program.

Marine, Estuarine, and Great Lakes

What information and methods are needed to support environmentally sound ocean disposal, estuarine, and Great Lakes programs?

Ocean Disposal: EPA is charged with regulating waste disposal activities in the marine environment. Among these activities are the dumping of wastes such as dredged material, the disposal of municipal and industrial wastewater through ocean outfalls, and the permitting of discharges through the NPDES program. An improved understanding of the ecological consequences of these ocean disposal actions is needed to guide future public policy, satisfy international marine treaties, and, where possible, protect and enhance coastal fisheries resources. Key questions concerning ocean disposal actions involve procedures to be used in assessing the impacts of ocean disposal and procedures necessary to evaluate long-term impacts and validate predictions made about potential impacts. The CWA requires secondary treatment for discharges from publicly owned sewage treatment plants, however waivers are allowed in selected cases.

Therefore, EPA must have a scientific basis for determining when secondary treatment requirements may be modified and what effluent limitations should be imposed.

To support the ocean dumping and outfall regulatory programs, EPA's research will focus on the development and validation of protocols needed for prediction of impacts from these activities. This program will continue the development and testing of ocean disposal impact assessment procedures, coastal monitoring methods, and procedures for characterizing the bioaccumulation potential and effects of ocean-disposed contaminants. In the next five years, increased emphasis will be given to research which supports ocean outfall related programs. At the same time, the emphasis on research related to ocean dumping activities is expected to decrease as a result of the Ocean Dumping Ban Act of 1988.

Coastal Waters: Estuaries and near coastal waters are valuable ecological systems that are directly important to man as fisheries and recreation resources and indirectly important as nursery areas for estuarine and coastal fisheries. These areas are subject to impacts from the production, transport, consumption, and release of toxic chemicals. In assessing the impacts from these chemicals, basic scientific uncertainties exist which involve the quantification of loads, their transport and fate, and their cumulative effects on resources. EPA's estuarine and near coastal waters research programs will concentrate on the development and validation of hazard-assessment protocols for improved source-control decisions in the NPDES Program. The estuarine research program will develop generic procedures for conducting wasteload allocations in estuaries. The coastal waters research program will focus on the development of biomarkers,

eutrophication, waste load allocation, and ecosystem resiliency/recovery.

Great Lakes: Increased use of industrial chemicals and their presence in the Great Lakes have raised public concerns about toxic pollutants, particularly persistent synthetic organic compounds. Because many of these compounds are complex, it is difficult to predict their impact on organisms in the food chain, including humans. Analytical methods for detecting environmental concentrations of organic compounds at trace levels are often inadequate. Also, existing methods are limited in their ability to relate pollutant exposure levels to sources and to determine biological availability and environmental effects of toxic organics. EPA will continue to study transport, fate, and effects of toxic materials in selected areas of the Great Lakes ecosystem, with emphasis on contaminated sediments. This information will be used by the Great Lakes National Program Office, EPA regions, states, and the International Joint Commission under the U.S./Canada Water Quality Agreement.

Wastewater Treatment Technology

What information is needed to develop and assist the states in implementing sludge disposal regulations and to improve the reliability and cost-effectiveness of wastewater treatment facilities?

Sludge Management: The processing and disposal of sludge accounts for about half the total operating costs of a typical sewage treatment plant. Municipalities are facing increased economic and public problems with current land and ocean sludge disposal practices. Approaches to disposal are needed that will significantly reduce the volume of sludge, destroy pathogens, ensure that toxic metals are not a problem, reduce toxic organic compounds, and ensure that sludge disposal does not present a threat to groundwater, the environment, and public health. To support EPA's regulations,

research will focus on sludge use criteria, procedures, and requirements applicable to the regulatory process. EPA will refine methods to assess sludge disposal options, including research into ecosystem resiliency or stress resulting from disposal and methods to predict human health effects from exposures to sludge.

Research on potential human health effects from sludge disposal involves collecting data on various chemical and bacteriological contaminants in sludges and sludge products and developing hazard indices for effects associated with different exposure pathways. Studies have been initiated to evaluate health hazards from exposures to sludge where composted sludge is sold as fertilizer. Results from these and other studies will provide data for determining the effectiveness of various sludge treatment processes in mitigating disease.

Health risk assessment profiles will support regulatory decision making on the effective treatment, conversion, use, and disposal of municipal sludge. EPA will continue to develop information on mitigating risk through sewage sludge treatment and on disposal options and will produce additional guidelines for conducting health risk assessments of sewage sludge disposal. Research results will be used to calculate indices for cancer and chronic toxicity related to hazards in the food web and inhalation toxicity and aquatic toxicity associated with the incineration and ocean disposal of sludge.

The Agency will continue to maintain and update the existing gas chromatography/mass spectrometry (GC/MS) tape library and will develop new analytical data bases of toxic pollutants found in industrial wastewaters. Assistance will be provided in the development of criteria for the assessment of hazard and risk exposure to pathogens from sewage sludge contam-

inants and provide guidance for evaluating the health risk of disposal practices.

Research on sludge stabilization, pathogen reduction, and dewatering offers a major opportunity to reduce substantially costs associated with sludge processing while incurring minimal environmental impact. Pilot and large-scale combinations of activated sludge and anaerobic digestion to determine the mass and volume-reducing capabilities of the system will be evaluated, along with promising methods such as mechanical composting and conversion of sludge to fuel. Engineering research addressing sludge applications in agriculture, forests, landfills, and land reclamation is needed to establish safe application rates and management techniques and to minimize surface and groundwater impacts.

Innovative/Alternative (I/A) Technology: EPA will provide technical and program support to states, municipalities, consultants, and equipment manufacturers in the areas of facility plan reviews, emerging technology assessments, technology evaluations, small wastewater flow technology, and technology transfer. Also, promising wastewater treatment processes that have had limited full-scale application will be assessed.

Upgrading and Correcting Designs: The Agency will provide information to municipalities to upgrade existing plant capabilities and achieve compliance with minimal capital costs. Research in this area encompasses evaluation of constructed wetlands, high biomass systems, enhanced oxygen transfer, and second generation nutrient control schemes.

Toxics Identification: EPA will identify and determine distribution of unlisted chemicals in industrial wastewater. Computer programs will be developed for searching stored GC/MS data from industrial wastewater samples for nonpriority pollutants; mass spectra will be compared with library spectra for compounds that

elude identification by spectra matching; these will be identified by reanalyzing samples using multispectra techniques.

Toxics Treatability and Toxicity Reduction: EPA will evaluate the fate and effects of toxic pollutants in municipal wastewater treatment systems as a component of efforts to develop enhanced control of toxics in such systems. The Agency will also develop toxicity reduction evaluation procedures for municipal and industrial wastewater treatment plants in support of water quality-based permit limitations.

Water Quality Planning and Regulation Support: EPA will provide engineering data and managerial techniques necessary for states to apply a cost-effective systems engineering approach to implement waste load allocations within their water quality control programs. This will provide more reasonable margins of safety in determining allowable stream loadings and reduce over-design of advanced treatment plants.

Quality Assurance: EPA will continue the quality assurance and repository samples program. The performance of major NPDES dischargers' laboratories will be evaluated, and actions on NPDES alternate test candidate procedure applications will be recommended.

Drinking Water Technology

What new technologies are needed to continue to assure the safety of drinking water?

EPA's drinking water technology research program provides engineering data to support the development and revision of drinking water regulations as well as engineering information and technological support to states, municipalities, EPA regions, and utilities concerned with drinking water regulations and compliance. Major technological problems include the relationship

between treatment strategies and deterioration of water quality within the distribution systems, other factors causing deterioration within distribution systems, and the need to bring small systems into cost-effective compliance. A related concern is the impact of distribution system corrosion on drinking water quality and the need for low-cost techniques to solve this problem.

Disinfection Byproducts: Research will continue on improving the knowledge of byproducts produced by chlorination as well as byproducts of alternate disinfectants such as ozone or chloramine. Evaluations of trihalomethane (THM) control using alternative disinfectants and treatment modifications will continue.

Overall System Integrity: The persistence and regrowth of organisms in distribution systems are influenced by the physical and chemical characteristics of the water, system age, pipe materials, and the availability of suitable sites for bacterial colonization. Investigations will also be carried out on other key factors that influence microbial regrowth, such as nutrients, temperature, and sediment accumulations. Theoretical, laboratory, and field studies will define factors associated with distribution system repair and replacement criteria. Laboratory and field studies will evaluate the impact of changes in treatment and disinfection practices brought about by existing and new regulations.

Small-System Compliance: EPA is directing special attention to small drinking water systems and their compliance with regulations. Research is evaluating the cost and engineering feasibility of specific treatment techniques to remove or control organic, inorganic, particulate, and microbiological contaminants. Field evaluations will continue on treatment technology at pilot or full-scale levels. Laboratory studies are defining variables that govern the effectiveness and

efficiencies of treatment processes prior to large-scale evaluations.

Monitoring and Quality Assurance: The Drinking Water Technology Research Program oversees the Agency-wide mandatory quality assurance program for drinking water. Ten regional laboratories are involved in the National Interim Primary Drinking Water Regulations laboratory certification program. Monitoring activities will also develop methods and total measurement systems for precise chemical, microbiological, and radiochemical analysis. This will provide accurate and cost-effective analytical procedures to monitor contaminants, disinfectants, and disinfectant by-products for use by the Agency, states, municipalities, and operators of public drinking water systems.

Drinking Water Health

What are the health effects from exposure to chemical and microbiological contaminants found in drinking water?

EPA is required to develop national drinking water standards for contaminants that may cause an adverse health effect. Research to determine the effects and risks from exposure to drinking water contaminants is an essential step and has been explicitly recognized by a provision of the Safe Drinking Water Act. Such research will be continued.

Health Effects Data and Risk Assessment: Toxicological research to develop dose/response data will support development of maximum contaminant levels and goals for disinfectants and disinfectant byproducts, synthetic organic chemicals, inorganic chemicals, radionuclides, and microbes as required under the Safe Drinking Water Act Amendments of 1986. Risk assessments and criteria documents will be developed for drinking water contaminants.

Methods Development: Research will be conducted to improve extrapolation of toxicological data from high to low doses and from laboratory animals to humans. The effects of different exposure pathways are being evaluated to improve the accuracy of risk assessments. Microbiological methods are being developed to identify infectious disease agents in water and to determine the significance of the occurrence of these agents in water supplies. Methods to determine exposure and risks from chemical mixtures are also being developed.

Groundwater

What is needed to improve the scientific capability to monitor, predict, and clean up groundwater contamination problems?

EPA and the states have a number of mandates for protecting groundwater, and almost every regulatory and enforcement program in the Agency has some interest in groundwater protection. In response to these needs, EPA's groundwater-related research programs cover aspects of source control, monitoring methods, analytical methods and quality assurance, assessment of transport and fate of contaminants in groundwater, and cleanup methods for contaminated soils and groundwater. This effort focuses on: wellhead protection, monitoring technology, prediction and assessment tools, underground injection control, aquifer cleanup, and technology transfer. These topics are also funded and conducted in the Hazardous Waste/Superfund/Underground Storage Tank (UST) and the Pesticides/Toxics areas but are not explicitly covered under those sections in this Research Agenda.

The research will be used to evaluate the groundwater flow, fate, and transport models available for wellhead protection and delineation. Approaches will be developed for assessing critical delineation factors

such as the radius of pumping influence around a well, the depth of drawdown of the groundwater supplying wells, and the time and rate of travel of contaminants in various hydrogeologic settings. In addition, the research would provide analyses of the threats to wellhead protection areas from sources of contamination and would evaluate the technical and institutional effectiveness of control methods on the prevention of groundwater contamination in those areas.

Predictive Methods: Predictive research provides the basis for assessing the risk of groundwater contamination on drinking water supplies and for understanding subsurface processes that may eventually lead to cleanup methodology. Sorption, biotransformation, transport, mixed solvent interactions, oxidation-reduction, hydrolysis, dechlorination, dispersion, fractured flow, and immiscible flow will be investigated for organic chemicals that could pose significant risk. Research will continue on virus survival and transport and metals mobility. Contaminant-transport models will be adapted and modified to include the improved process descriptions. Field evaluations will determine the degree of confidence that can be expected from predictive models in various hydrogeologic environments. Applications of models for wellhead protection programs will be evaluated.

Monitoring Technology: EPA's research will improve cost-effectiveness and accuracies of monitoring in three areas: methods, geophysical techniques, and interpretive analysis. Sampling and well construction methods will be evaluated to determine their effects on the accuracy of results. Fiber optics technology will be studied as an inexpensive and reliable groundwater monitoring option.

Current methods will be adapted for use on underground storage tanks and nonhazardous landfills. Vadose zone (unsaturated) techniques will be eval-

uated for their applicability to various situations and soil-gas monitoring will be developed into an inexpensive and reliable method for plume delineation.

Geophysical methods adapted from the energy and minerals resource industry will be evaluated for their applicability to such groundwater contamination problems as detecting leakage from underground injection wells, location of abandoned wells, and contaminant plume detection. Quality assurance methods will be developed and standardized to improve confidence in these techniques.

Interpretive analysis will be used to obtain more information from monitoring data and to improve reliability. Efforts will continue to determine the completeness of coverage for methods to locate abandoned wells. "Variance analysis" will be applied to determine the frequency of sampling required in monitoring wells to gain the appropriate confidence under differing circumstances. A strategy has been developed for wellhead protection research. Finally, geographically based information systems will be used to make groundwater monitoring data more useful to decision makers.

Underground Injection Control: This research will be extremely important over the next few years due to the regulatory requirements of the Hazardous and Solid Waste Amendments of 1984. EPA is required to reconsider the safety of underground injection as a hazardous waste disposal method and to ban such injection should there be migration out of the injection zone. EPA has a number of research activities under way to aid the Office of Drinking Water in making these determinations, including determining the fluid movement from wells and describing the interaction of injected fluids with the geological strata. Research will focus on methods to test the mechanical integrity of wells, to

locate abandoned wells, and to control practices associated with shallow, nonhazardous injection wells.

Aquifer Restoration: Aquifer cleanup research will provide cost-effective methods for cleanup of contaminated soils and groundwater. Alternatives are needed to current approaches such as withdrawal and treatment or containment. Promising laboratory methods for enhancing subsurface biotransformation will be field tested.

Wellhead Protection: This program has expanded in response to requirements of the 1986 amendments to the Safe Drinking Water Act. A newly completed five-year strategy document lays out the plans for the program. The research areas include wellhead delineation method testing and improvement, assimilative capacity, multiple source risk assessment, wellhead protection in agricultural regions, monitoring strategies, and technical assistance/technology transfer.

Technology Transfer: Information transfer will continue to be an important part of groundwater research. Specific training materials are under development in addition to technical assistance to EPA regions and states. Direct training of regional and state personnel will continue, and the International Ground-Water Modeling Center, a clearinghouse for groundwater models and training, will continue to be supported. In addition, Technical Assistance Documents will be prepared for use by states in the development and implementation of their Wellhead Protection Program.

Summary of Long-Term Trends

Most of the water research issues described in this chapter will continue into the next decade, with gradually changing degrees of activity and emphasis. Better analytical capabilities will continue to improve the ability to measure trace constituents in water,

resulting in better identification of greater numbers of potentially deleterious chemical contaminants. With more toxicological and epidemiological information, water quality managers will face increasingly difficult decisions involving the environmental significance of complex mixtures of pollutants.

A significant near-term issue includes the development of toxicant information for complex mixtures. The growing inventory of chlorinated organic contaminants in complicated combinations requires significant changes in the research strategies and technological methods used to assess them. Whole-sample evaluations such as matrix bioassays, biological indicators, and chemical surrogates will play a larger role in the future. To remain responsive, EPA's water research program must simultaneously develop and validate new methods for evaluating complex mixtures and their impact when applied in regulatory situations.

The environmental water quality issues, including estuary protection, ocean disposal, and the water quality based approach, all reflect the emerging need to develop new tools to test and monitor ecological impacts such as effects on the community at a system level. In ensuing years, major strides will be made in identifying safe or "no-effect" levels of toxic organic contaminants in sediments and water and in methods to establish biological availability and bioaccumulation in tissues of aquatic organisms.

Many communities and landowners rely upon groundwater sources for drinking and irrigation. Questions regarding the quality of groundwater have been increasing in recent years. Consequently, the dynamics of groundwater and the residence times and fates of leached contaminants in aquifers will be a major water resource issue for the remainder of the century. The coming years will see the refinement of the capability to simulate and predict the impacts of contaminants on

underground sources, and cleanup technology will become more important.

In the wastewater treatment areas, emphasis will be on control of toxics in wastewaters and sludges, improved engineering, and the periodic emergence of innovative and alternative technologies to reduce costs. A major breakthrough in wastewater treatment may come from biological engineering, possibly through the development of organisms that could be more effective in treating wastewater and sludges than other methods.

Pesticides/Toxics

1989 Current Estimate: $ 41.5 million
1990 President's Budget: $ 42.3 million

Projections ($ in millions)

Growth	FY 1991	FY 1992	FY 1993	FY 1994
None	42.3	42.3	42.3	42.3
Moderate	43.6	44.9	46.3	47.7
High	44.9	47.6	50.4	53.5

Pesticides and toxic substances research provides support to meet the current and future needs of the Toxic Substances Control Act (TSCA); the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA); the Asbestos Hazard Emergency Response Act (AHERA); to some extent, the Federal Food, Drug and Cosmetic Act (FFDCA); and Title III of the Superfund Amendments and Reauthorization Act (SARA). Research efforts are geared toward providing scientifically valid yet cost-effective methods for evaluating the risks associated with pesticide uses and the manufacture, use, and release to the environment of new and existing chemicals.

The research program in support of the above Acts will continue to develop, evaluate, and validate health, exposure, and environmental test methodologies and procedures to improve the predictability of human and environmental risk estimates and to develop exposure monitoring systems, environmental fate and effects methods, and guidelines to perform ecological risk assessments. Additional research will develop and evaluate release and control methods for new and existing chemicals, structure activity relationships as predictors of chemical fate and biological effects, and procedures for ensuring the human and environmental

safety in the manufacture and use of biotechnology products. Methods development and validation studies, evaluation of asbestos abatement techniques, and contamination of groundwater from pesticides are other areas of interest in the ongoing research program.

Major Research Issues

Test Method Development

What new procedures or tests are needed to ensure that industry's data on environmental or health effects are accurate, reproducible, and consistent?

Under TSCA and FIFRA, manufacturers must test chemicals and pesticides for potential hazards to public health and the environment. Consequently, research is conducted to develop standard methods, to develop or evaluate improved, more cost-effective methods, and to provide quality assurance materials for performing such tests. Regulatory decisions on a chemical depend on qualitative and quantitative scientific data from industry regarding potential adverse environmental and human health effects of exposure to the chemical.

The monitoring program will focus on the development of methods to assess chemical residues in humans, in human tissue and fluid, in the environment, and in biota. Human exposure methods research will focus on advances in supercritical fluid chromatography, GC and LC/MS analyses, ICAP-MS analyses, and the development of biochemical and immunochemical markers to detect exposure to particular pollutants. New efforts will focus on the study of infrared spectra to develop and validate effective, economical analytical and biological methods for routine measurements. Methods will be developed to determine the effects of agricultural pesticide use on the quality of surface and groundwater systems.

In the environmental effects research program, methods are being developed, validated, and evaluated for environmental toxicity testing to determine the sensitivity of available tests and to identify species for potential future test methods development. In this area, major advances will be required to relate single-species and microcosm data to actual ecosystem effects and to adequately relate observed effects on one species to probable effects on other species. Carcinogenic effects methods will be studied. Parameters influencing test results will be evaluated. Testing applications are designed for assessments and monitoring. This continuing effort to improve testing methods is required in order to enable measurement of effects of new chemicals or formulations on a select array of organisms, providing an information base for guidelines and discussions.

Health effects research efforts are directed toward developing and validating predictive, reliable, and cost-effective in vitro and in vivo test systems. Test methods development will focus on the prediction of toxic hazards in the following areas: reproduction/teratology, neurotoxicity, immunotoxicity, genotoxicity, and carcinogenicity for inclusion in test guidelines to be used by pesticide registrants and in Section 4, TSCA testing requirements.

Structure Activity Relationships (SARs)

What information needs to be developed on substances and their similarity of chemical structure to determine the additional testing needed to assure the safety of humans and the environment?

To enhance the efficiency of the regulatory process for toxic substances, it is convenient to group various chemicals that share common or similar chemical characteristics rather than to deal with each individual chemical. If it can be demonstrated that chemical relationships, such as similar molecular structures and

similar modes of toxic activity, form a firm scientific basis for estimating probable environmental risks, then better guidelines and techniques can be applied and regulatory actions can be completed more quickly using fewer resources. This approach will provide both the regulator and the regulated a standard basis for determining if a substance might be toxic and detrimental to living organisms or their environment.

SARs are important for reviewing and screening premanufacture notification (PMN) chemicals under Section 5 of TSCA. The findings and techniques established in this research will be used to select appropriate toxicity tests, to document test results, to develop fate and effects data bases where necessary, and to provide the modeling means to predict toxicity.

Environmental effects research will include data base compilation and improvement in the precision and validation of SARs for predicting toxicity. Studies will include assimilation of fate parameters such as photolysis, biodegradation, and likely metabolites in multimedia matrices. Quantitative SAR models are being refined and used to estimate acute toxicity for fish, chronic ecotoxicity for fish and invertebrates, bioconcentration factors, and transformation (microbial) rate constants. Systems will be developed to define metabolic pathways and rates of metabolism, while some research will focus on specific modes of toxic action.

Health research will focus on the development of methods using a combination of descriptors based on molecular structure to predict genetic, carcinogenic, and other toxic activities through pattern recognition, statistical, and thermodynamic techniques. Data bases containing bioassay data for use in predicting the mutagenic and carcinogenic potential of new chemicals in the environment will also be expanded. Quantitative dose-effect data are also developed on specific

compounds and classes of chemicals to aid in predicting the toxicity of structurally similar chemicals.

Special Human Data Needs

What effects do specific chemicals have on actual populations occupationally or environmentally exposed to the chemicals?

To improve the Agency's ability to estimate human health risk, these activities will examine population groups exposed to environmental contaminants that are suspect toxicants. Research is continuing to determine whether biological indicators of dose and/or effects are related to environmental levels of exposure and if they are correlated with adverse effects measured by traditional methods. This includes DNA adducts, nervous system specific proteins, and metabolites in blood and urine. Laboratory estimates of molecular dose will be used for epidemiology studies of humans highly exposed to toxic agents.

Ecology: Transport/Fate/Field Validation

What methodologies (including mathematical models) are needed to assess the fate and effects of toxic chemicals and pesticides in the environment?

To adequately evaluate the likelihood of perturbations a pesticide or toxic chemical may cause in the environment, it is necessary to understand probable exposure concentrations/durations, movements through ecosystems, degradation rates, reservoirs, effects, and residues. The Agency must have available techniques that may be applied to attain this information, and it must be able to interpret findings and prevent problems. Activities in this area are designed to meet these needs, to improve the criteria and standards with which industry, the users, or the Agency must comply. The intent is to provide new or improved state-of-the-

art techniques to fill data gaps in order to have scientifically credible and legally defensible regulatory actions.

Research for TSCA will include evaluation of microcosms as bioassay units along with studies at various seminatural and field sites in freshwater, estuarine/marine, and terrestrial habits. Exposure studies will provide information and data banks used to predict the effects of toxic chemicals. Modeling will be emphasized as an analytical and predictive tool. Methods will be devised and data concerning biodegradation, cometabolism, mixture effects, rate constants, and soil-related factors such as kinetics and transformation processes and influencing environmental factors will be assimilated for modeling use.

System level studies will examine benthic aquatic problems, applying single species and cluster analysis approaches to project community level effects. Comparative toxicology will address sensitivity of various organism life stages to pollutants, while terrestrial evaluations will include determination of effects of pollutants on soil processes and on wildlife, which shows immunotoxic and reproductive response from dietary and other stressors when subjected to pollutants.

Response of green plants to toxic substances will also be studied.

Pesticide-oriented investigations will focus on representative estuarine, freshwater, and terrestrial field sites and will consider pesticide dose, exposure, effects, and functional alterations at the species/population level. Nontarget organism (e.g., fish, invertebrate, crustacean, bird) effects will be quantified in terms of mortality, reproduction rates, and resiliency. This includes residue analysis and population census (pre- and post-treatment) information. Through extensive field sampling, data collection and analysis, and simulated exposures, field findings will be compared to lab findings. Final evaluations will be published indicating

where lab results are comparable to field results and indicating if hazard assessment criteria are adequate. Additionally, laboratory and field studies will determine the relationships among the use of pesticides and other agricultural practices, pesticide characteristics and field conditions, and resultant pesticide concentrations in groundwater to mitigate groundwater contamination problems.

Transport and fate processes and exposure information are highly critical to the Office of Pesticides and Toxic Substances (OPTS) operations. Various laboratory tasks will contribute exposure information based on such parameters as sorption kinetics in sediments, pesticide transformation, biodegradation, and movement in the environment. Rate constants will be derived and the extent of chemical reactions determined in order to describe mathematical expressions that will lead to estimates of exposure concentrations. Mechanisms and rates of degradation by natural microbial communities will be studied. Controlling environmental conditions and processes affecting degradation will be determined, factoring in quantitative relationships between the pesticide chemical characteristics and the environmental parameters.

Field evaluations of methods and exposure models (with emphasis on leaching models) will be conducted through laboratory and field studies, including analyses of residues in soils. This includes information generation on the variability of soil water releases and groundwater contamination and on model calibration and improvements to predict exposure concentrations and toxicant movement. Groundwater research studies for the validation of pesticide exposure models will be emphasized. Appropriate workshops and symposia may be convened to transfer results to users. When developed and evaluated, these models will predict the

environmental impact of pesticides and toxic substances.

Health: Markers, Dosimetry, and Extrapolation

How do we relate external dose to internal dose and to early indicators of disease states, and how can we better extrapolate (from high dose to low, from one route of exposure to another, and from laboratory animal to man) to support risk assessments?

For both the pesticides and toxic substances programs, health effects research will be focused on developing methodologies for extrapolation of animal data from high to low doses, between mammalian species, and between different routes of exposure to reduce the uncertainties in human health risk assessment. Additional studies in the toxic substances research program involve defining the relationship between environmental exposure, internal dose, and biological response in clinical and laboratory studies. Pharmacokinetic studies and modeling will be carried out. Additional pesticides research includes evaluating the relationship(s) of age and dermal absorption using in vivo animal models as well as research on compound-induced reproductive alterations following exposure during developmental periods.

In addition, for both pesticides and toxic substances programs, biological markers will be reviewed for their capacity to indicate episodes of exposure. Monoclonal antibodies and biomarkers such as enzyme induction and protein/DNA adducts will continue to be evaluated as potential screening tools for human exposure.

Exposure Monitoring

What improvements are needed for the monitoring methods, systems, and analysis used to provide the data bases for estimating human exposure?

TSCA-related monitoring efforts will be directed toward improvements in monitoring instruments and systems to estimate human exposure. Applications of Geographic Information System (GIS) technology to risk assessment will be developed. A GIS is a computer program that locates data and links data bases through geographic coordinates. Factors used in risk assessment, such as hydrology, point sources, drinking water intakes, and Census data, are located geographically and linked together in a format resembling a base map with overlays. Methods of incorporating GIS data bases into existing fate, transport, and exposure models will be explored. A GIS method of estimating the number of people exposed to releases from a point source using Census and land use data is currently being developed. Studies relating concentrations of volatile organic chemicals in blood to those in breath will be compared. Statistical survey procedures will be developed and tested for use in microenvironment studies. Random and spatial multivariable techniques of chemometrics, which include pattern recognition such as correspondence analysis and spatial pattern recognition, are being evaluated with existing data sets to solve problems in QA and QC and monitoring data. Also, statistical techniques are being applied to composite sampling, multivariate outlier, and performance evaluation tests to address program needs. Human activity pattern models and data analysis techniques will be developed.

Biotechnology/Microbial and Biochemical Pest Control Agents

What methods and technologies are being developed to provide risk assessment data to evaluate microbial agents and other products of biotechnology?

Many of the techniques required to adequately assess the potential risk associated with use of genetically altered or unaltered micro-organisms apply to both

TSCA and FIFRA mandates. Products of biotechnology used as pesticides are subject to FIFRA; most other biotechnology products (e.g., industrial chemicals, biodegradation products, fertilizers) are subject to TSCA. FIFRA products are evaluated for their environmental effects, as they are designed to be deliberately released. TSCA products are evaluated for their potential health and environmental effects, on the basis of workplace exposure and accidental or deliberate release.

Producers of biotechnology products must follow recommended Agency guidelines in a testing regime designed to estimate potential adverse environmental/health impacts. ORD helps establish these techniques (used to determine if effects on nontarget organisms may be anticipated) and conducts field validation studies to ensure that testing criteria and guidelines are appropriate and functional. The research develops or improves methods to monitor, contain, or destroy micro-organisms in industrial and environmental settings. In addition, methods to sample genetically engineered micro-organisms (GEMs) released into the environment from industrial facilities will be standardized, and exposure models for estimating worker risk will be developed. This research will provide a basis for monitoring and testing guidelines for TSCA PMN and FIFRA EUP submissions for genetically engineered micro-organisms.

Under FIFRA, ecological research will develop or improve bioassay methodologies for determining environmental effects on nontarget receptors or hosts. This includes providing testing protocols and effects information for unaltered and genetically engineered microbes. Investigations focus on routes of exposure, methods to detect and identify agents, toxicity, infectivity, persistence, gene transfer, and ecosystem effects.

This information will be included in Subpart M guidelines and will be used for regulatory decisions.

Health research involves development of data on the effects of microbial pest control agents on mammalian cells. Immunological methods are being developed using monoclonal antibodies and DNA probes to enable the identification of genetic material from biological pesticides in nontarget sites. The results of this research will provide the basis for validation of Subpart M guidelines for testing microbial pesticides. Monitoring research will focus on evaluation of measurement techniques to produce guidelines governing field release of genetically engineered micro-organisms.

Under TSCA, efforts will continue to evaluate, develop, and standardize scientific rationales, procedures, and instruments to monitor the environmental survival, reproduction, distribution, effects, and risks associated with the release of genetically engineered micro-organisms. The impact of genetically engineered micro-organisms on human exposure will be studied to determine the potential for adverse health effects. The results will be used to prepare protocols and quality assurance guidelines for use in evaluating the impact of released micro-organisms and to develop field test requirements for release of genetically engineered micro-organisms.

Engineering Release and Controls

What engineering and technological information is needed to predict the release of and exposure to toxic substances and to determine alternatives for control of these substances?

Under the PMN process, manufacturers are required to submit information to EPA on the release and control of new chemicals and significant new uses of existing chemicals. EPA uses existing data and methodologies to predict the risks associated with the release of new

substances, and, under the existing chemicals control program, evaluates technological alternatives to reduce the release of and exposure to chemicals that are already in use.

Models are being developed which will predict the release of and exposure to classes of new chemicals from chemical-unit operations and processes during manufacture. Additionally, models to identify the best measures to control release of and exposure to new chemicals will be developed. Treatability testing of potentially toxic chemicals such as azo dyes are being conducted.

Alternatives to mitigate the release of and exposure to specific existing and new toxic substances will be defined through the evaluation and adaptation of existing control measures. Technologies, management practices, and personal protective equipment to limit release and exposure are being evaluated and methodologies developed to test their effectiveness. For asbestos, in addition to evaluating cost-effective control technologies, research will include characterizing durable replacement fibers and evaluating the long-term effectiveness of removal techniques and decontamination procedures.

Under FIFRA, EPA is responsible for assessing pesticide exposure studies, for reviewing and approving pesticide labels, for administration of the pesticide Farm Safety Program, and for supporting training and education programs for pesticide users through state extension services. Engineering support in the pesticide disposal area consists of (1) providing technical assistance including the evaluation of various proposed disposal/treatment methods, (2) developing a pesticides-treatment data base, and (3) reviewing regulations. ORD will identify the more promising methods of treatment/disposal and prioritize their effectiveness for the destruction of a target pesticide class or subclass.

In addition, an improved technology for processing rinsates and a test system to ensure that a potentially recyclable container is free of pesticide residual will be identified or developed. ORD will make available to the public a treatability data base that will provide a concise review of pesticides and the effectiveness of various treatability methods. Finally, ORD will review storage, transportation, and disposal-labeling regulations for the Office of Pesticides Programs to ensure technical compatibility.

Ecology: Ecotoxicity and Risk Assessment

What methods are needed to evaluate ecosystem risk as a result of exposure to existing and new chemicals?

Ecosystem risk research will provide a scientifically based system to assess ecological risks from exposure to environmental toxicants. This system will have the capability to assess risks associated with different uses of chemicals by considering various options for regulating pesticides and toxic chemicals to protect organisms in their natural environment. This research will provide for prognostic assessment, extrapolations to any patterns and levels of environmental release, inferences of types of responses to be expected in natural systems, and estimates of uncertainties in the assessments. Finally, it will integrate chemical fate, exposure, and effects to enable the user to conduct risk assessments for terrestrial and aquatic systems.

This information will be integrated through a computerized framework linking all components to facilitate appropriate analyses and produce results in any desired form. The studies will include data bases of scenarios such as river reaches, endangered species habitats, chemical properties, and characteristics of organisms including geographical range and habitat preferences. Activities will use and develop traditional analysis techniques and models that calculate biocon-

centration and effects for populations, communities, and ecosystems and provide quantitative and qualitative probability statements of uncertainties involved in the assessments.

Support

What support is required for preparation and review of scientific assessments and for quality assurance?

While most TSCA and FIFRA risk assessments are conducted by the EPA OPTS Program Offices, for certain assessments the technical expertise of the ORD staff is used to interpret data or provide technical and scientific opinions and judgments. In cases where program office evaluations are complicated and/or controversial, independent peer review of assessments is used to ensure consistency. There is a continuing need for ORD participation in and review of major exposure and hazard assessments conducted by OPTS, for supplying Agency policymakers with technical assistance from qualified scientists, and for improving the scientific basis of Agency decisions in regulatory matters.

ORD also provides critical review of test rule documents for existing chemicals. These reviews support validation of toxicity tests and assist with exposure and risk assessments and with preparation and update of TSCA testing guidelines. This support also encompasses evaluation of complex problems associated with environmental fate, hazards, and risks of toxic chemicals and bioengineered organisms as necessary for implementing TSCA.

ORD also advises OPTS on the development and implementation of laboratory qualification programs to identify asbestos in the environment, provides chemical reagents and quality control samples for use in TSCA and FIFRA monitoring schedules, and provides guidelines for applying models in exposure monitoring under

TSCA. Support is also provided for laboratory data audits.

Summary of Long-Term Trends

Pesticides and toxic substances research efforts focus on both intentional and unintentional releases of chemical substances into the environment. Each of the issues covered in this chapter will continue into the next decade. Various degrees of emphasis are addressed below.

Test method development efforts will continue in support of both TSCA and FIFRA guidelines. As current methodologies are standardized, new techniques will be developed to fill gaps in existing methods. These new methods will focus mainly on endpoints other than carcinogenicity and will provide more effective means to conduct quantitative risk assessments. To this end, efforts will increase for developing extrapolation techniques (from high to low doses and from animals to humans) that reduce the uncertainties in estimating human health risk. The development of biological markers will also assist in this area by providing more accurate measures of human exposure levels as well as serving as tools for epidemiological studies. Concurrently, the development of exposure monitoring systems will increase to provide new monitoring methods, systems, and analyses to more accurately characterize human activity patterns and total human exposure.

Ecological risk assessment research will continue to develop methods and models for determining the fate and effects of chemicals. These exposure methods and models will provide the means to evaluate risks. The integration of such methods and data will enable the development of protocols for environmental risk assessments. Ecological research will continue to validate fate, transport, and effects techniques and

applicable testing guidelines required by the Agency for scientific credibility and defensible regulations.

Research to provide information on the release and control of new and existing chemicals from manufacturing processes will allow the rapid and accurate prediction of how much and where chemicals will be released into the environment and, with increasing accuracy, an estimate of associated exposure and impacts. Treatability of chemical wastes and degradation products will be better defined to improve characterizations of risk. Such information is vital to the PMN review process, and it is anticipated that the need for such data will continue to increase as the manufacture of new chemicals continues to grow.

EPA will provide methods to protect public health and the environment from the potential adverse impacts of microbial agents and the products of biotechnology. This research will help to determine containment facilities for bioengineered organisms, means of monitoring the survival and distribution of those intended for release, and controls for inadvertent releases.

Hazardous Waste/Superfund/UST

1989 Current Estimate:

Appropriated funds: $ 45.4 million
Trust funds: $ 74.1 million

1990 President's Budget:

Appropriated funds: $ 42.3 million
Trust funds: $ 69.3 million

Projections ($ in millions)

Growth	FY 1991	FY 1992	FY 1993	FY 1994
None	111.6	111.6	111.6	111.6
Moderate	114.9	118.4	121.9	125.6
High	118.3	125.4	132.9	140.9

The Resource Conservation and Recovery Act (RCRA) authorizes a regulatory program to identify wastes that pose a substantial hazard to human health or the environment and develop waste management standards that protect human health and the environment. Research support for this program provides the scientific and engineering basis for characterizing wastes, determining the hazards they pose, and formulating controls. Research is also conducted to support the leaking underground storage tank (UST) provisions of RCRA.

The Office of Emergency and Remedial Response (OERR) requires scientific research and technical support from the Office of Research and Development (ORD) to investigate and mitigate health and environmental problems at the priority sites listed under authority of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986. ORD's research program provides a core of scientific and technical

information to support the implementation requirements of CERCLA and the enforcement actions undertaken to obtain cleanup and recovery costs. It concentrates on assessing health and environmental risks posed by Superfund sites and on evaluating equipment and techniques for detecting, identifying, assessing, controlling, removing, and disposing of hazardous substances released into the environment. Research and support activities consist of programs to develop and evaluate the validity of methods for detecting and evaluating adverse human and environmental effects, to evaluate alternative control and removal technologies, and to develop effective monitoring systems.

The ORD program for Superfund includes research designed to enhance the Agency's capability to respond to Superfund problems in general, as well as to respond to more comprehensive site-specific evaluation needs for Superfund sites. Plans provide for site-specific assessments, quality assurance, and technical support for the monitoring program; technology transfer activity; innovative/alternative treatment and detection technology research; development and demonstration programs for both monitoring and engineering; research on health effects, health risk assessment, and support to Regional Offices for risk assessment activities; support in environmental exposure and risk assessment; and support to the Regional Offices in the areas of groundwater sampling, analysis, and data interpretation by the multidisciplinary groundwater support team.

Major Research Issues

Alternative Technologies

What will ORD do in the effort to reduce the source and generation of pollution?

ORD will embark on a pollution prevention research program that will emphasize technology transfer of

innovative approaches to pollution prevention and tools for assessment and decision making in support of EPA's new Office of Pollution Prevention.

The research and development components include a waste reduction innovative technology evaluation program. This will consist of cooperative agreements with states to identify and evaluate new production and recycling technologies. The effort will also include a technology clearinghouse.

What information and data are needed to support and permit the use of alternatives to land disposal?

The Agency is implementing the program that will ban land disposal of certain classes of untreated hazardous wastes. Banning these wastes could require the availability of proven alternatives for treating or recycling waste materials. Although many of these technologies currently exist, many questions are asked about their effectiveness on specific wastes and their capacity to address the anticipated volumes that will require treatment. This research will provide support for the Office of Solid Waste (OSW) in implementing the portions of the RCRA amendments which require banning certain hazardous wastes from land disposal.

Research on alternative technologies assesses the performance of the major alternatives now under development, and, in selected instances, supports the evaluation of processes found by the Agency to offer substantial improvements over conventional hazardous waste disposal methods. Such evaluations will be conducted and used with existing data to form the basis for treatment standards.

Assessments of alternative technologies are conducted at bench, pilot, and field scales with emphasis on waste streams assigned high priority by OSW. Included will be aqueous waste streams from the chemical

industry that are likely to be banned from landfills and wastes with a high potential for volatile air emissions.

What technologies are appropriate to clean up priority sites?

The ORD program for Superfund has been expanded from its start-up level to implement an innovative/alternative treatment technology demonstration program at the level authorized by SARA. The Agency is conducting 10 demonstrations per year to accelerate the commercialization of innovative/alternative treatment technologies that will clean up priority sites.

Engineering evaluations of emerging technologies to accelerate private development will be increased. Technologies to be developed will continue to be selected from applications submitted to the Agency in response to solicitation in the Commerce Business Daily. The focus will continue to be in the areas of recycling, separation, detoxification, destruction, and stabilization that promise significant new methods for cleaning up Superfund wastes.

This activity will also provide increased testing and evaluation of newly developed but unproven innovative fast-response monitoring techniques for applicability to Superfund monitoring situations. In addition, promising advanced/innovative monitoring techniques and systems which are not yet ready for demonstration will continue to be further developed so that their utility for Superfund pollutant characterization can be demonstrated.

The technical improvement of commercially available or prototypical protective clothing, equipment, and procedures for use in responses at Superfund sites will continue to be identified, evaluated, and promoted. Reports on personnel hazard detectors, personnel cooling devices, vital signs monitors, and intra-EPA and interagency workshops will be provided.

Technology-specific evaluations for Superfund will continue to be provided in the major technical areas of in-situ and on-site treatment. The emphasis will be on providing engineering information for the remediation process. In addition to activities on extraction, detoxification, and immobilization processes, new efforts will include identification, at laboratory and pilot scale, of processes most suitable for soil fractionation in the field, as a function of the type and particle size distribution of soils. Such techniques would help in minimizing on-site treatment and disposal costs.

In microbial cleanup (biosystems), technologies will continue to be applied and evaluated for use in program office responses to Superfund sites. The emphasis will be on the use of techniques to enhance the metabolism of hazardous substances by indigenous microorganisms and the use of specially engineered microorganisms at actual field sites. Such techniques are potentially more effective and less costly than currently applied cleanup methods.

Site Assessment and Support

What information and technical support is available for site-specific risk analysis and risk reduction?

This program will also continue to provide site-, situation-, and chemical-specific exposure and risk assessments to assist the program office and regions in evaluating the degree of hazard at uncontrolled waste sites. Specific activities will include preparation of site/situation-specific risk assessments, Health and Environmental Effects Documents, and, in conjunction with the Agency for Toxic Substances and Disease Registry, Toxicological Profiles for use in Remedial Investigation/Feasibility Studies (RI/FSs) and other remedial planning efforts.

This activity will continue to generate chemical-specific carcinogenicity and chronic effects documentation

to support the program office's regulatory process, which lists substances as CERCLA "Hazardous Substances" and calculates or adjusts their Reportable Quantities (RQs). This support will allow the Agency to continue the normal RQ adjustment activity, to complete adjustments pursuant to the additional requirements placed upon the Agency by SARA of 1986, and to consider other chemicals for listing as CERCLA Hazardous Substances and for calculation of RQs. Finally, review of previously calculated RQs will be performed on request from the program office or when significant new data become available.

With the acceleration of cleanup activity, a significant increase in enforcement activity is expected. This will increase the need for endangerment assessments for enforcement. Site- and chemical-specific health assessments will be prepared to respond to situations requiring endangerment assessment at Superfund sites. Assessments to be provided will range from brief hazard summaries to many detailed, peer-reviewed endangerment assessments for use in negotiations or litigation with potentially responsible parties. Review of regional risk assessments will continue. This will include providing a central point for coordinating review of regional risk assessments and establishing a focal point for regional offices to request risk assessment assistance. Forty-eight hour turnaround of needed health assessments will continue.

Increased resources will allow enhanced efforts to evaluate, validate, standardize, and field test monitoring techniques to support program office monitoring at sites. Analytical methods for hazardous substances at sites will continue to be validated for Superfund waste matrices.

Site-specific monitoring support will provide aerial imagery, photographic interpretation, and other technical support to OWPE, OERR, and the regions for use

in pre- and postremedial site assessment. Geographical information systems will generate data for analysis of present and historical site operations and conditions at waste sites. Air monitoring techniques will be evaluated to provide source monitoring methods at sites. Geophysical methods will be developed and validated for groundwater and subsurface characterization.

Engineering expertise will continue to be provided to assist the program office in RI/FS of specific Superfund sites during efforts to plan responses. Updated RI/FS treatability and cost estimation information will continue to be provided.

The engineering program will continue to advise and consult with the program office on technical issues that arise during emergency and remedial responses at Superfund sites and will offer support to Enforcement for cases under way.

Technical support will continue to be provided in response to specific requests from OWPE, OERR, and regions on groundwater sampling, analyses, data interpretation, and site assessment and remedial action issues. Increased emphasis will be given to the application of bioassessment techniques for determining acute toxicity and bioavailability of Superfund wastes, extent of contamination, and remedial action progress, and in transferring this technique to others in the public and private sectors. Other activities will include: the application of assessment methods to determine the appropriate control technology for minimizing the risks from contaminated marine sediments, which is important for limiting the uptake of hazardous materials by marine organisms and their impact on humans through the food chain; the application of emerging biotechnology techniques to Superfund sites for improving in-situ cleanup through biodegradation processes (biosystems); and the application of multimedia exposure/risk assessment methods to Superfund sites.

An increased level of technology transfer assistance in issues relevant to Superfund cleanups will be provided to the program office, regions, and states.

Hazardous Substances Research

What research information is needed to assess health risks from hazardous substances?

Research to improve health risk assessment data generation and methods will be provided in this program. Efforts will be expanded in research to understand risks posed to reproductive health resulting from exposure to chemicals, on development of risk assessment methods, on development of exposure information obtained and applicable in the field, on development of pharmacokinetic methods, on development of microcomputer-assisted risk assessment tools, and on methods to better characterize the risks from chemical mixtures. Additional efforts will be undertaken to evaluate the role of promoters found at waste sites in carcinogenesis, development of biologically based dose-response models, and improvement of techniques for route-to-route extrapolation.

In the health effects research program, emphasis will be on research dedicated to improving health risk estimates performed during site decision making. Research for improved Superfund risk assessments will continue on the health effects of toxicant combinations and complex mixtures, on identification and use of genetic and dosimetric biomarkers for human exposure to hazardous substances and their effects, on predicting target doses from knowledge of the relationships between exposure and dose, and on development of additional tools for hazard identification at Superfund sites. Research will also continue on the health impacts of various cleanup options (incineration, biosystems) and on development of biomonitoring methods for postremedial site review.

Development, demonstration, and validation of promising field screening techniques having potential to provide improved Superfund pollutant characterization will be pursued. Field deployable monitoring technologies such as x-ray fluorescence, fiber optic sensors, portable gas chromatography, and immunoassays provide rapid site characterization information, thereby contributing to accelerated site cleanup. Innovative air and groundwater sampling techniques improve the ability to accurately characterize site contamination. In addition, increased efforts will be expended in development of monitoring systems that are useful in integrated multimedia health assessments.

Waste Characterization

What risk assessment information and procedures are needed to characterize wastes and assess the hazards they represent?

Assessing the risks associated with various methods of waste disposal is a critical aspect of the Agency's RCRA program but is an area of major scientific uncertainty. Developing the scientific and technical information needed to establish the quantity and types of wastes that escape into the environment through different disposal methods, the effects they produce for both human health and the environment, and the methods for assessing their risks will remain a significant area for research activity for some time. Moreover, given that most existing information is based on the properties of individual chemicals, rather than the complex mixtures of chemicals typically found in wastes streams, the state-of-knowledge in this area will require several years to develop.

A program to develop more accurate methods for predicting the quantity, composition, and volatility of leachates from land disposal of wastes is under way. These and other methods for determining the escape of hazardous wastes into the environment, as well as

predictive models in air, surface water, and groundwater, will have to be combined into multimedia tools for exposure assessment. Products of this research will be critical for the Agency's land-banning and groundwater programs.

Chemical-specific Health and Environmental Effects Documents (HEEDs) will be prepared to support RCRA 3001 listing decisions. Support will also be provided to the Agency's effort to ban land disposal of certain wastes and will include evaluation of Reference Doses (RfDs).

Environmental processes research will include development of multimedia assessment models for land disposal sites and groundwater models for predicting waste concentrations. Research addressing complex mixtures will be expanded to allow better characterization of their environmental toxicity for use in decisions on delisting, banning, and permitting.

Waste Identification

What analytic methods are needed for identifying the chemical constituents of wastes and thereby determining which wastes are hazardous?

Additional analytical methods for implementing Section 3001 of RCRA must be standardized and tested to determine their validity and reliability. New methods and procedures for detecting the presence of hazardous wastes under field conditions are also required to help implement Section 3013 of RCRA, which authorizes EPA to establish facility monitoring requirements.

New hardware and software developments offer considerable promise for reducing cost and time, while improving sensitivity, of laboratory analyses. Examples of the emerging technologies are supercritical fluids, quadrupole-mass-spectrometry, and thermospray injection liquid chromatography. Considerable effort will

be directed to evaluating and applying such technologies for hazardous waste analyses. One particular thrust will be in the development of technologies for rapid screening of large numbers of samples, particularly groundwater samples. A second effort will be toward obtaining more comprehensive chemical profiles of volatile and semivolatile organic chemicals in solids and other complex matrices. Research on the applications of high performance liquid chromatography will contribute to methods development for less volatile organics. Concurrent with these activities will be a continuing effort to upgrade the computer programs supporting the analytical equipment, with special attention to computer interpretations of measurements.

This program will support activities in the following areas: development of bioassays into a screening protocol for detecting hazardous waste; development of subsurface monitoring and network design protocols for detecting potential groundwater contaminants; validation of published SW-846 analytical methods; and development of new, more cost-effective analytical methods. These will include inductively coupled plasma and high performance liquid chromatography. Additional emphasis will be placed on addressing RCRA subtitle D facilities, and, as part of this, monitoring and quality assurance practices at these facilities will be assessed.

Land Disposal

What technical information is needed to support permitting of land disposal and land treatment facilities, as well as improvements in design requirements?

Research in this area will provide guidance on design, permitting, operation, maintenance, and closure and regulation of land treatment, storage, and disposal facilities. It will also address controlling air emissions from facilities and include sampling and measurement

procedures, evaluation of emission models, and evaluation of control technologies.

Incineration

What technical information and data are needed to support permitting of incinerators and improvements in design requirements?

Results of this research will be used by EPA and other permitting officials to evaluate the acceptability of incinerating particular wastes and in monitoring operating units for compliance with performance requirements.

As the Agency begins banning certain wastes from land disposal, various disposal alternatives will become increasingly popular, including incineration. However, in order to issue permits for incinerators, Regional Offices and the states will require technical information and assistance regarding their performance capabilities. Ensuring the safety of their operation will require that methods be developed to predict their performance, and that their reliability be increased through control of operational parameters which avoid formation of hazardous byproducts. The development of methods to monitor incinerator emissions is instrumental to determining emissions standards.

A newly developed risk assessment methodology will be applied to specific situations as needed, and this methodology will be amended to take into account disposal of incineration ash and risks from other thermal destruction processes.

Research will continue to produce performance tests on incineration of wastes burned at the Combustion Research Facility. Real-time methods of determining incinerator compliance with permits will be investigated, as will improved sampling techniques for monitoring thermal destruction operations. Guidance manuals for

states, regions, and industry will be produced addressing the best practices for burning wastes in industrial boilers, assessing health risks from incinerator operation and from residual wastes, and assessing the impacts on emissions of incineration failures. Bioassays will be applied to generate data for assessing the risk from various burner methodologies. Bioassays for cancer and for noncancer effects will also be applied. Health effects data and a comprehensive risk assessment methodology for municipal waste incineration will be provided, and full-scale comparative testing of selected air pollution control devices for municipal waste combustion will be conducted.

Releases

What procedures and information are needed to contain and clean up accidental discharges of hazardous materials?

Research under CERCLA will support both the CWA's releases section and RCRA's UST provisions.

Accidental releases of oil and hazardous material to the land and water occur frequently and constitute a significant environmental hazard. Federal, state, and local emergency response personnel require improved technologies for the control of hazardous material releases to make cost-effective, environmentally sound cleanup decisions. Technologies used to provide information on accidental releases include aerial photography, satellite imagery, and multispectral scanners.

Geophysical/geochemical sensors, volatile organic emission sensors, sensor placement networks for detecting leaks of hazardous materials from USTs, and establishing boundaries of contamination will be developed and evaluated. Test protocols for determining appropriate performance criteria will be developed as well. External monitoring techniques and systems, those noncontiguous to the tank or line, will be

evaluated. Approaches will include computer models, physical models, and field monitoring.

Evaluations of leak detection and monitoring methods for USTs will be produced, as will guidance manuals on nondestructive techniques for locating buried tanks and on UST release prevention techniques. A continuing effort throughout this period will be the evaluation of new technologies for the prevention and cleanup of releases. Innovative new systems will be sought, and if shown to be feasible, field-evaluated.

Quality Assurance

What measures are needed to assure the reliability and consistency of monitoring and analytical techniques and data used in support of the RCRA and Superfund programs?

The purpose of this program is to ensure that data of known quality are used throughout the Hazardous Waste Program. Analytical standards and reference materials of many matrices will be developed for and distributed to all participating laboratories. Quality control and performance evaluation samples are also being developed and distributed to appropriate laboratories. Technical support will be provided to all participating laboratories in the form of instrument calibration assistance and provision of reference materials.

For Superfund, this program will provide quality assurance support to the Agency's Contract Laboratory Program, additional precontract assessment of proposed contract laboratories, calibration materials, laboratory performance assessment, and evaluation/improvement of analytical methods. Methods to assure the quality of sampling activities will be developed to complement the analytical quality assurance research program.

Summary of Long-Term Trends

Research to characterize the potential exposure and effects posed by hazardous wastes is likely to be an area of significant importance. In order to effectively manage risk, answer the questions and concerns of the public, and make the policy choices that will have to be made, more will have to be learned regarding the identity, behavior, and health and ecological effects of hazardous materials released into the environment.

Development and evaluation of alternatives to land disposal of wastes will remain an Agency priority. Research remains in its early stages, and considerably more work is needed before alternatives will be able to satisfy the disposal requirements of large-scale generators. Extensive testing and performance evaluations are needed to make these technologies available, and years of effort will be required. Research will also be accelerated to provide support for the land-banning program and to support RCRA UST provisions.

Emphasis will also continue on research supporting the Agency's groundwater program and on identifying the problems associated with municipal waste combustors. Groundwater research will focus on determining groundwater pollutant transport and fate and developing the monitoring technology needed to identify problems and measure the effectiveness of mitigation techniques. Applications of biological techniques for site cleanup will be determined. Research addressing municipal waste combustors will identify the pollutants they produce, assess the hazards they may pose, and determine the monitoring and control technologies needed to address the problems. Development of field methods for in-situ analysis at waste sites is planned to continue.

Multimedia Energy

1989 Current Estimate: $ 54.9 million
1990 President's Budget: $ 38.2 million

Projections ($ in millions)

Growth	FY 1991	FY 1992	FY 1993	FY 1994
None	38.2	38.2	38.2	38.2
Moderate	39.4	40.5	41.8	43.0
High	40.5	42.9	45.5	48.2

The Multimedia Energy research program addresses those pollutants originating from energy sources. The primary objective is to provide the scientific information necessary to permit the development and use of the nation's energy resources in an environmentally acceptable manner. The Multimedia Energy research program addresses two areas of research: the acid deposition research program and the Limestone-Injection Multi-Stage Burner (LIMB) control technology demonstration and development program.

Acid deposition research is coordinated with other Federal Agencies through the National Acid Precipitation Assessment Program (NAPAP), which is administered by the Interagency Task Force on Acid Precipitation. EPA chairs the six member Interagency Joint Council of the Interagency Task Force. The term "acid rain" is used to refer to the atmospheric deposition of acidic or acid-forming compounds in either their dry or wet form. These compounds exist in the atmosphere as gases or aerosol particles and include sulfur oxides (SO_x), nitrogen oxides (NO_x), hydrogen chloride, sulfuric acid, nitric acid, and certain sulfate and nitrate compounds. The objectives of acid deposition research are to develop the necessary data to understand and quantify the sources and characteristics of

acid deposition, to determine the extent of current damage or potential damage, and to predict changes in damage for specified changes in emissions. This information is essential to the development of effective corrective strategies if such strategies are deemed necessary.

The other major research area is the development and demonstration of LIMB emission reduction technology. LIMB technology combines low NO_x burners with upper furnace sorbent injection for control of SO_2 emissions. The EPA-industry cofunded wall-fired boiler demonstration testing began in 1987. A tangentially fired boiler demonstration with cofunding from EPA, DOE, and industry was initiated in 1987, and testing will commence in 1990. Successful demonstration of this technology may substantially lower the capital and operating costs of retrofit SO_2 and NO_x control.

Beginning after the 1990 President's budget issuance, the planning of the activities contained in the Multimedia Energy section of the Research and Development program will be carried out by the Air and Radiation Research Committee.

Major Research Issues

Emissions Inventories of Acid Precursors

How can emissions inventories be made more responsive to acid rain modeling and assessment needs?

Estimates of current emission rates (aggregated at the national level) are reasonably accurate for major categories of man-made acid deposition precursors. However, atmospheric transport models under development will require improvements in spatial and temporal resolution of emissions estimates. During 1990, three emissions models, AUSM, ICES, and PROMPT, will be completed. The efforts to project future emissions rates and to estimate the cost of alternative

emissions-control strategies are dependent upon the development or improvement of models that replicate the behavior of each important "emitting sector" of the economy. The engineering cost studies scheduled for completion in 1990 must be consistent with methods that have been fully reviewed by the engineering and economic communities.

Atmospheric Processes Affecting Acid Deposition

How can the transport, chemical transformation, deposition processes, and the exposure of ecologically sensitive areas and man-made materials be determined?

Our understanding of the atmospheric transport, physical and chemical transformation, and deposition processes of pollutants emitted into the atmosphere continues to improve. The program's focus has evolved to emphasize evaluation of the Regional Acid Deposition Model (RADM) and to quantify the uncertainty of its predictions.

Field data to evaluate the model will be generated to improve our scientific confidence in RADM. RADM will be used in a number of important areas (e.g., to assess engineering applicability and cost control, to perform source-receptor analysis, and to assess materials damage). The RADM will enable policymakers to predict changes in deposition levels resulting from changes in nearby or distant emissions.

Dry-Acid Deposition Monitoring

What is the best method to obtain dry deposition monitoring data comparable to that from the existing National Trends Network (NTN), which concentrates on wet deposition?

The acid rain research program has compiled several years of nationwide deposition data from wet precipitation. Dry sources of acid deposition in the form of

gases and particles constitute a potentially significant component of total deposition. Very little data exist on this dry deposition due to the difficulty in developing and deploying accurate monitoring instruments for routine applications. ORD has established a National Dry Deposition Network (NDDN) to better measure the actual contribution of dry deposition. These monitors are being deployed in a network, colocated with wet deposition collectors and ecological monitoring stations.

Aquatic Effects of Acid Deposition

What future changes in surface water chemistry and fish populations will occur assuming various levels of acid deposition, and what is the extent and rate of change to aquatic resources stemming from acid deposition?

The Aquatic Effects Research Program was developed to determine the effects of acidic deposition on surface waters of the United States. The program focuses on four policy questions: (1) What is the extent and magnitude of past change attributable to acidic deposition? (2) What change is expected in the future under various deposition scenarios? (3) What is the target loading below which change would not be expected? (4) What is the rate of recovery if deposition decreases? The goal of the program has been to characterize and quantify with known certainty the subpopulation of surface waters which will respond chemically to current and changing acidic deposition and to determine the biological significance of observed or predicted changes. The Aquatic Effects Research Program has five major component programs designed to increase understanding of long-term acidification: the National Surface Water Survey, the Direct/Delayed Response Project, Watershed Manipulations and Processes, Long-Term Monitoring, and Indirect Human Health Effects. Short-term acidification is being addressed through the Episodic Response Project. The Biolog-

ically Relevant Chemistry Project addresses issues of both chronic and acute acidification.

National Surface Water Survey: The National Surface Water Survey has collected high quality baseline data over several years on a variety of aquatic systems. These data have been used to prepare estimates of effects and to classify systems. Work on the National Surface Water Survey will be completed during 1990.

Direct/Delayed Response Project: The Direct/Delayed Response Project, which analyzes watershed response to acidic deposition in the Northeast, the Southern Blue Ridge Province, and the Mid-Appalachian region will be completed in 1991. This effort employed multivariate statistical procedures, empirical models, and dynamic watershed models to correlate future watershed response estimates with the current resource status. These classification procedures and protocols will contribute to the development of dose-response relationships through predictions of acidification or recovery of surface waters.

Watershed Manipulation and Process Studies: These studies provide long-term verification of Direct/Delayed Response Project forecasts and identification of processes and watershed interactions controlling surface water acidification through a number of highly integrated soil process studies. Some of the Watershed Manipulation Project studies will be integrated with the Episodic Response Project. Other studies will be implemented to determine if the Direct/Delayed Response Project dynamic models and other more simplistic, steady-state models can be used to predict recovery in response to lower levels of acidic deposition relative to current levels.

The Little Rock Lake acidification study, which has examined chemical and biological response to direct additions of acids, providing data for examination of a

number of acidification-related hypotheses, will be closed out.

Episodic Response Project: The Episodic Response Project will refine estimates of the size of the aquatic resource that is subject to intermittant periods of acute acidity. The Episodic Response Project focuses on acquiring biologically relevant chemical data to gain a better understanding of biological effects due to acute acidification, principally effects on fish. The specific objectives are to understand the frequency, duration, and magnitude of episodes, the key factors that influence their occurrence, and the impact episodes have on fish populations.

Data from intensive experimental studies on hydrochemical and biological processes, along with limited surveys of chemistry and fish (including bioassay data), will form the basis for developing regionally applicable models of chemical and biological response. After calibration and verification, the models will be applied to the statistical frame of the National Surface Water Survey to provide estimates of biologically relevant chemical data, as well as effects on fish on a regional basis.

Synthesis and Integration: A major emphasis for the program since 1987 has been the development of the classification scheme described above. These analyses are the foundation for the aquatics portion of the 1990 NAPAP Integrated Assessment. Because not all components of the program are expected to be completed in time to contribute to the assessment, synthesis and integration will continue beyond 1990. Key issues to be examined beyond 1990 include determining the influence of episodes on surface water response, providing data on potential nitrate acidification to refine dose-response relationships, and to establish critical loads of nitrogen to sensitive watersheds and estuaries, and corroborating or modifying

acidification and recovery predictions through long-term monitoring.

Terrestrial Effects of Acid Deposition

What is the effect of acidic deposition, alone or in combination with other pollutants, on forests?

Forest effects studies in acidic deposition have been focused in the Forest Response Program, jointly funded and managed by the EPA and Forest Service. This program was initiated in 1983 in response to public concern over the role of acidic deposition and air pollutants in forest decline.

The mission of the program is threefold: (1) to determine if acidic deposition, alone or in combination with other pollutants, is causing or contributing to forest decline in the U.S., (2) if so, to determine the mechanism of effect, and (3) if so, to determine the dose-response relationship of forest response to loadings of acidic deposition, alone or in combination with other pollutants.

To meet the goals of the Forest Response Research Program, research has been organized to include historical data analysis, controlled lab and field experiments, site investigations, and monitoring. Research will be undertaken by Research Cooperatives organized by forest type. In areas where phenomena have been reported, field investigations and historical review activities concentrate on examining forest condition in relation to atmospheric deposition and natural factors. These cooperatives also sponsor controlled lab and field studies to test hypotheses of damage relevant to forest type and deposition scenario.

The Mountain Cloud Chemistry Program is investigating the potential causes and mechanisms of tree dieback and reduced growth rates at higher elevations in the East. The tree dieback in some locations

appears to increase in severity with increasing elevation. To address this research need, monitoring stations are established on the slopes and summits of selected mountains and are colocated with forestry research stations. Samples from the network of forest research and monitoring stations will be analyzed and archived by a central laboratory. Preliminary results suggest that tree dieback and reduced growth rates on mountains are due to a combination of severe climate, exposure to ozone, and exposure to acidified clouds.

Materials Damage from Acid Deposition

What is the quantitative relationship between acid deposition and damage to structures, buildings, and other materials?

Qualitative relationships between acid deposition and resulting damage have been identified for a few materials under various conditions of exposure. The current issue is to quantify the rate of damage as a function of acid deposition. Damage functions will be derived from physical chemistry theory, chamber studies, and field exposure studies. This program has been concluded except for the completion of state-of-the-science reports for the NAPAP assessment.

Summary of Long-Term Trends

A major focus of the Acid Deposition program over the last several years has been to create the necessary analytical tools and models and to assemble the knowledge and information that will provide the input for the 1990 NAPAP Assessment Report to the Congress. As the time for the preparation of that report has approached, several projects and components of the Acid Deposition research program have been completed, resulting in a general phasing down of the research program. The scale and direction of future acid deposition research will be considered along with the findings of the NAPAP report. In future years, the

remaining Acid Deposition research will be planned and described as a component of the Air research program.

Interdisciplinary

1989 Current Estimate: $ 39.4 million

1990 President's Budget: $ 77.7 million

Projections ($ in millions)

Growth	FY 1991	FY 1992	FY 1993	FY 1994
None	77.7	77.7	77.7	77.7
Moderate	80.1	82.5	84.9	87.5
High	82.4	87.3	92.6	98.1

The interdisciplinary research program covers several broad scientific activities which are not tied specifically to media-related concerns. The interdisciplinary research program includes seven major components: (1) the operation and coordination of all ORD technical information, technology transfer, and general regulatory support activities; (2) operation of the Agency-wide Quality Assurance program; (3) conduct of long-range exploratory research through the research grants, centers, small business innovation research grants, and the visiting scientists program; (4) promoting consistency and scientific quality in agency risk assessments through the development of risk assessment guidelines, and methods, and by seeking concensus among agency scientists on risk assessment scientific issues; (5) reducing the uncertainties inherent to the health risk assessment science through a research program targeted to improve risk assessments by addressing the major data gaps and uncertainties; (6) improving our knowledge and understanding of human exposure in order to better estimate risk; and (7) an environmental status and trends program which focuses on developing the information and methods to better estimate environmental risk.

Major Research Issues

Promote Consistent Risk Assessments

What activities and methods are needed to ensure scientific consistency and technical quality in Agency risk assessments?

This function has four major components: development of risk assessment guidelines, activities of the Risk Assessment Forum, research to reduce uncertainties in risk assessment, and managing the Integrated Risk Information System (IRIS).

The first risk assessment guidelines were issued in 1986. These included guidelines for carcinogenicity risk assessment, mutagenicity risk assessment, health risk assessment of suspect developmental toxicants, and health risk assessment of chemical mixtures and estimating exposures. In 1988, the Agency proposed guidelines for assessing risk to the male and female reproductive systems. New guidelines are expected to be published for neurotoxicity, making and using exposure measurements and noncancer health effects, and amended guidelines will be published for cancer and developmental toxicity. Work will be initiated on guidelines for including pharmacokinetics in risk assessments. The Agency recognizes that guidelines are living documents and are therefore subject to revisions and expansions, which will take place as they are appropriate. Also included will be coordination of interagency activities to address issues and data gaps identified in the guidelines.

The Risk Assessment Forum was established in 1984. As stated in its charter, it promotes consensus on risk assessment issues and ensures that this consensus is incorporated into appropriate risk assessment guidance. To fulfill this purpose, the Forum formally assembles Agency risk assessment experts to study and report on these issues from an Agency-wide scientific

perspective. Forum activities may include: developing scientific analyses, risk assessment guidance, and risk assessment methodology for use in ongoing and prospective Agency actions; using scientific and technical analysis to propose risk assessment positions; and fostering consensus on these issues. Generally, the Forum focuses on generic issues fundamental to the risk assessment process, on the analysis of data used in risk assessment, and on developing consensus on approaches to risk assessment.

IRIS is a computer-based file of EPA risk assessment and risk management information for chemical substances. It is designed especially for federal, state, and local environmental health agencies as a source of the latest information about EPA health assessments and regulatory status for specific chemicals. It is intended for users without extensive training in toxicology but with some knowledge of health sciences. Inhalation reference doses are being added to IRIS. An upgraded version of IRIS will make the system easier to understand and use and to accommodate the rapidly expanding number of users.

Technical Information and Liaison

What activities facilitate technology transfer to regions, states, and affected local governments?

ORD, as the primary research arm of EPA, provides scientific information needed by the regulatory offices of EPA to develop and enforce regulations. Appropriate and timely dissemination of research results supports the scientific basis for EPA regulations and increases confidence in the decision-making process.

The Center for Environmental Research Information (CERI) provides centralized support for the production of information products in a cost-effective manner; ensures consistent, uniform dissemination of research results; and provides a technology transfer program to

synthesize information and develop presentations to more effectively support specific high-priority program objectives at the lowest cost to the government.

CERI will continue to provide support to ORD laboratories by writing summaries of research projects conducted by or for ORD, editing documents and summaries, assuring the quality of material submitted for printing, typesetting and producing documents, assuring the quality of and preparing documents for submission to the National Technical Information Service, controlling the distribution of documents, and responding to requests for publications and documents.

The technology transfer program will assess the status of research and regulations, discuss with the Research Committees their priorities for the dissemination of material, develop innovative information transfer mechanisms, and ensure that information on improved technology and management practices is distributed to appropriate audiences to comply with EPA regulations. All information on products is developed using a team of participants from ORD, EPA program offices, and private industry.

Planned activities include:

- Development of methods manuals for comparing different solid and hazardous waste treatment techniques and implementing those that are appropriate;
- Dissemination of the results of research on the control of hazardous air pollutants;
- Description of technologies, costs, and operating effectiveness of the methods available to meet drinking water regulations for small drinking water systems;

- Dissemination of information on the effectiveness, cost, and design of new municipal waste treatment technology;
- Development and dissemination of state-of-the-art technology transfer mechanisms such as: expert systems; computer animated graphics; computer assisted instruction; and desk-top publishing; and
- Establishment and operation of the ORD Regional Scientist Program which is designed to place a senior ORD scientist or engineer in each EPA Regional Office to serve as a liaison between ORD and EPA regions and their client states, municipalities, and tribal governments. Regional scientists will assist in the identification of priority research and technical assistance needs and facilitate appropriate ORD responses.

Exploratory Research Program

How will the Agency conduct longer-range mission-oriented research that is not tied to specific regulatory timetables or program office requirements?

Such research will be conducted through the Office of Exploratory Research. The goals of the Exploratory Research program are

1. To make the environmental research community aware of and active in working on problems of interest to EPA;
2. To promote close interaction and mutual awareness between EPA researchers and the environmental research community; and
3. To provide general support to the research community for work on fundamental environmental research, thereby promoting a solid foundation of

knowledge and a cadre of scientific and technical personnel in the environmental sciences.

These goals are achieved through four major programs: (1) a Research Grants Program that provides grant support to investigator-initiated research in the environmental sciences and engineering, (2) an Environmental Research Centers Program and a Hazardous Substances Research Centers Program that provides funding via cooperative agreements to universities to conduct interdisciplinary research under specific research themes established by EPA; (3) a Visiting Scientists and Engineers Program that attracts outside scientists and engineers to EPA laboratories to conduct research in collaboration with EPA researchers; and (4) a small business innovation research program which provides research support to high-tech businesses with innovative ideas for pollution abatement and control.

To date, the Research Grants Program has supported about 600 research projects in priority areas as identified by the Agency's planning mechanisms. The Environmental Research Centers Program currently supports research conducted at eight university-based research centers on various topics of priority interest to the Agency. The Visiting Scientists Program has attracted 23 scientists/engineers to EPA facilities for up to 3-year terms to collaborate on research projects.

Research Grants Program: A primary function of the Research Grants Program is to stimulate extramural scientists to work on EPA's technical problems and to provide a stronger creative base of mission-oriented research needed for the Agency's regulatory and enforcement efforts.

The Research Grants Program solicits investigator-initiated proposals by issuing annually a solicitation document that describes EPA's high-priority, long-term research needs. The solicitation is broadly

distributed and is intended to stimulate scientists in the academic, research, and industrial communities to respond with fully developed proposals for innovative research in areas of interest to EPA. Although all valid proposals are considered, the solicitation has typically emphasized research needs in five interdisciplinary program areas: environmental health, environmental biology, environmental engineering, chemistry and physics in air, and chemistry and physics in soils and water. In the future, the emphasis may change to include ORD's major research initiatives.

When the Agency wishes to expand an existing research area or explore a new one in which current Agency efforts are either minimal or nonexistent, targeted grants are awarded in a narrowly defined research topic. The purpose of these exploratory grants is to augment existing research within EPA with more fundamental studies or to determine whether a more substantial research effort should be established by the Agency in the area targeted for study. The Office of Exploratory Research addresses this specific research need by issuing a special solicitation called a request for applications (RFA). The RFA is a mechanism by which a formal announcement is released describing a high-priority initiative in a well-defined scientific area.

The grants selection process uses a dual review system of evaluating research proposals. Ad hoc panels, chaired by scientists or engineers from outside EPA, meet at least twice annually to discuss reviews of each proposal conducted by at least three experts in the relevant field. Applications that pass the scientific panel review are then reviewed by Agency personnel for their relevancy to the Agency's mission. The combined recommendations are rank-ordered and the grants are awarded based upon the availability of funds.

Grant support is typically awarded for two to three

project officer. Project monitoring is accomplished by the submission of technical progress reports and/or the publication of scientific papers in peer-reviewed journals. Staff and formal site visits are conducted when appropriate.

The five interdisciplinary areas of the Research Grants Program are described below.

Research Grants in Environmental Health: The major objective of the Environmental Health Research Program is to obtain and provide a scientific basis upon which the Agency can make regulatory decisions concerning the protection of human health from environmental pollutants. The principal concern is to determine whether, and to what extent, exposure to various pollutants contributes to environmentally related health problems. Particular attention in the annual solicitation is given to epidemiological studies, animal toxicology, bioassay development, and mechanisms of action. Major areas of new emphasis will deal with understanding the mechanisms of inducement of disease and pathology, improving the validity of assays as predictors of potential human risks, and developing better model systems to determine the long-term effects of multimedia pollutant exposure.

Research Grants in Environmental Biology: The Environmental Biology Research Program supports a broad range of projects in the areas of ecosystem effects, aquatic ecosystem modeling, biotechnology monitoring, environmental assessment, marine studies, and biodegradation in water and soil environments. The aim of the program is to provide a base of scientific knowledge which can be used to identify new and emerging problems and to develop appropriate remedies for their solution. One objective of this program is to provide information that, in combination with exposure data, allows the prediction of the environmental risk of pollution for individual organisms and

ecosystems. The risks include the reduction of productivity in agricultural areas, wetlands, and freshwater and coastal marine ecosystems as well as human exposure to toxic substances through accumulation in the food chain.

During the next five years, emphasis will focus on wetland problems and the development of modeling methods for predicting the ecosystem effects on wetlands. Another area of focus will be the development of methods for monitoring genetically modified organisms in the natural environment.

Research Grants in Environmental Chemistry and Physics/Water: The Environmental Chemistry and Physics of Water Program supports research leading to basic scientific tools for establishing the levels at which pollutants occur or might occur in the environment under different conditions.

The program includes projects in analytical chemistry and studies on chemical reactions and their rates and on the physics of the movement of pollutants in the water and soil. The resulting tools and information allow the estimation of exposure levels needed for risk assessment. The research also provides possible approaches to the treatment of waste sources. It includes small-scale laboratory studies and large-scale field projects relating to the transport and transformation of pollutants.

This program will emphasize problems related to groundwater, sediments, and measurement methods. For groundwater, the emphasis will be on developing the techniques for estimating the parameters used in transport models and in validating the models. In the case of sediments, the focus will be on the physics of movement and the capability of sediments to transport pollutants, particularly heavy metals. Research on measurement methods will continue with some

emphasis on methods applicable to sediments and associated substances such as humic materials.

Research Grants in Environmental Chemistry and Physics/Air: The Environmental Chemistry and Physics of Air Program is concerned with the study of the sources, transport, transformation, and fate of air pollutants. The program reviews applications dealing with studies on time-space patterns of pollutant concentrations, detailed chemical and physical descriptions of pollutants, mathematical models connecting air pollutants with probable sources, and procedures for investigating the impact of pollutants on human health. The program draws on the concepts and procedures of physics, chemistry, and meteorology using models and measurement methods to develop quantitative descriptions of these phenomena.

This program will emphasize models or other means of connecting air pollutants at a location with the contributing sources, the atmospheric chemistry of polyaromatic hydrocarbons (important toxic compounds), and reliable measurement techniques for detecting the particulates of significance to health.

Research Grants in Environmental Engineering: The Environmental Engineering Research Program supports more basic fundamental research needed to provide solutions to multimedia pollution control problems outside the scope of the Agency's response-directed research program. Therefore new, innovative pollution control and waste management techniques are sought to provide cost-effective solutions to complex problems involving air, water, and soils. Areas emphasized include water disinfection, wastewater treatment, water-related process biomonitoring methods, residuals control, and air pollution concerning VOCs, fine particles, SO_x, and NO_x. Hazardous wastes continue to receive particular attention,

especially incineration processes and improved cleanup techniques.

Environmental Research Centers Program: As part of EPA's strategy for approaching long-term research needs, ORD has created the Environmental Research Centers Program to support environmental research in science and engineering. The objective of the program is to support high-quality exploratory research in areas of importance to EPA. It is achieved by providing stable funding to institutions with a demonstrated capability and interest in a major area of research of concern to EPA. The program, which was established in 1980, consists of eight university-based environmental research centers working in four general areas: (1) industrial and municipal waste abatement and control, (2) pollutant transport and transformation, (3) ecological and biological effects of pollutants, and (4) environmental epidemiology. Each broad area of research is discussed below.

Environmental Research Centers for Industrial and Municipal Waste Abatement and Control Research: Three centers conduct research in this area. The Industrial Waste Elimination Research Center (IWERC) focuses its attention on reducing or eliminating the creation of pollutants. Two centers, the Advanced Environmental Control Technology Research Center (AECTRC) and the Hazardous Waste Research Center (HWRC), study the removal of wastes once they are formed. The AECTRC works primarily on the removal of contaminants from dilute waste streams, such as sewage discharges and stack effluents, while the HWRC studies methods to stabilize, detoxify, or destroy waste products containing high concentrations of hazardous pollutants.

The principal areas of research at IWERC, listed in order of current priority, are: (1) metals speciation and separation, (2) sorption/desorption phenomena, (3)

particle size and shape control, and (4) process catalysis and control. This priority list is not expected to change significantly, though more emphasis will be placed in the future on process and catalysis control, and on particle size and shape control.

AECTRC has investigated the degradation of low concentrations of organic contaminants in drinking water sources using biofilm systems. This work is expected to expand in the future, as is work on the supercritical extraction of pollutants. Current work on wet air regeneration of powdered activated carbon will be de-emphasized. In the area of air pollution, AECTRC will increase efforts on studying the simultaneous collection of submicron aerosol particles, sulfur dioxide, and oxides of nitrogen. With respect to the indoor radon activities, a systematic study will be made of the adsorption of radon on charcoal as a function of charcoal type, design parameters of the collection system, and interference from other gaseous species.

The HWRC will continue to emphasize the destruction, separation, and stabilization of hazardous waste constituents, particularly the development of optimal design parameters for complete or nearly complete incineration of combustible organic hazardous wastes. Future research will focus on: (1) the operation and modeling of a full-scale industrial incinerator, (2) in-situ biodegradation of targeted environmental toxins in soil, (3) investigations of the feasibility of rotary kilns as low energy thermal desorbers for soil and solid waste contaminated with organics, and (4) the transport mechanisms involving pure organic phases in the unsaturated and saturated zones below spill and dump sites.

Environmental Research Centers for Pollutant Transport Research: Two centers study the movement and alteration of pollutants in the environment.

The National Center for Ground Water Research (NCGWR) devotes itself to understanding the movement and alteration of pollutants through the subsurface environment. Directly or indirectly, groundwater is the major source of the nation's drinking water, but it may be contaminated with pollutants from a wide variety of sources. Efforts to mitigate this contamination are complicated by the extremely slow movement of pollutants underground.

In the next five years, the NCGWR will emphasize studies on subsurface biodegradation and on facilitated transport of trace organic compounds in saturated aquifers. Future studies will deal with microbial metabolism as a process involved in the fate of contaminants. The comparative ecology of aerobic microbes as influenced by subsurface parameters such as soil type and electron acceptors will be studied in order to predict and control microbial involvement in the fate of contaminants at hazardous waste disposal sites. Current work on subsurface anaerobic environments will be expanded to include isolation of chemical intermediates and end products. Another new project will be initiated, using state-of-the-art optical techniques, to determine whether sorption of contaminants is dominated by organic carbon or mineral surfaces.

The other center, the National Center for Intermedia Transport Research (NCITR), studies the important physical and chemical processes associated with the transport of particulate or gaseous environmental pollutants from one medium to another. Current and future studies at NCITR will emphasize the movement of hazardous wastes through air, land, or water.

Specific projects at the NCITR will concentrate on five topics: wet and dry deposition, soil and water processes, multimedia transport, ecosystem modeling and structural characterization, and source allocation. Plans for research include development of an improved

correlation between dry deposition velocity and the roughness layer; determination of the ambient compositions and concentrations of organic pollutants in rain, fog, and dew; studies on the chemisorption of halocarbons by clay; and the mitigation of organic pollutants in the unsaturated soil zone. In addition, NCITR will maintain current levels of research on studies to determine the significance of nitrogen-bearing trace compounds in air to nitrogen levels in desert ecosystems, the transfer rate of submicron aerosols to vegetation, and the effects of vegetation on the transfer of atmospheric pollutants.

Environmental Research Centers for Ecological and Biological Effects Research: Research on ecological and biological effects is conducted at two centers: the Ecosystems Research Center (ERC) and the Marine Sciences Research Center (MSRC). The mission of the ERC is to evaluate the state of knowledge on whole biological communities and ecosystems and to investigate its applicability to environmental regulation and management. Research conducted at ERC is in the areas of ecotoxicity, biotechnology, air pollution effects on forests, plant-pest interactions, and impact assessment for the Hudson River system. ERC has also developed projects in two additional areas. The first of these, functional classification of ecosystems, has as its eventual goal the classification of ecosystems into functional types, both in terms of the natural rates at which processes occur and in terms of their responses to anthropogenic disturbances. The other area of research is freshwater wetland ecosystems. The purpose of this project is to develop concepts and methods for simplifying assessment of the effects of human-induced changes in hydrology on northern freshwater wetlands.

The objective of research at the MSRC is to increase understanding of processes in coastal marine ecosystems that are of importance in evaluating the

effects of pollutant discharges. The primary approach to research at MSRC is experimental; specifically, the use of mesocosms as models for predicting the responses of biological communities in coastal systems to pollutant loadings, and to determine the fates of pollutants. Such mesocosms fill a gap between laboratory experiments and field observations.

A major shift in research emphasis at MSRC is occurring. Previous studies emphasized the determination of the fates and biological effects of sewage sludge, fuel oil, and specific hydrocarbons. These studies were "passive" in the sense that they described impacts of pollutants on coastal systems. In the future, more emphasis will be placed on studies whose objective is to recommend methods for control of unsightly, odorous coastal waters, rather than simply predict the occurrences of such events. MSRC has developed a program to determine the efficacy of silica enhancement of ocean outfalls to control the explosive growths of phytoplankton (e.g., red tide) often associated with mephitic waters. Another major effort is a field program to evaluate the state of Narragansett Bay with respect to a number of environmental features related to pollution or other anthropogenic effects. This effort is being carried out in cooperation with other studies of pollutant inputs, shellfish health, bacterial contamination, hydrodynamic modeling, etc., in association with the Narragansett Bay Project, also supported by EPA.

Environmental Research Center for Environmental Epidemiology Research: The area of environmental epidemiology is addressed by one center, the Center for Environmental Epidemiology. Its primary objective is to improve the theoretical understanding of the human health risks associated with environmental pollution. The center has established four research priorities: (1) problem definition and feasibility assessments for epidemiology studies; (2) research to develop and improve epidemiological methods related to

environmental health, for example, research on statistical and analytical methods; (3) research on exposure assessment relevant to epidemiological investigations; and (4) research support to EPA, including review of data and reports, and identification of problems where epidemiology can support EPA's mission.

Emphasis is given to indoor air contamination, where research will focus on inhalation exposures to volatile constituents from water used for purposes other than drinking. A project relating to volatile constituents from shower water will be completed and a new study initiated to determine the source, strengths, and dissemination of indoor volatile and gaseous constituents from water and other materials. Plans will be made to extend this project to measurements of organics in exhaled air of humans in homes where environmental exposures have been well characterized. This research will be a joint project between the University of Pittsburgh and Carnegie-Mellon University.

Efforts will be directed toward better characterization of environmental contamination. Work will be carried out on the development of a passive sampler which has optimal properties for the routine monitoring of airborne vapors at very low concentrations such as are found in the general environment.

Some preliminary investigations will also be made in an area new to the center. This area is characterized by heterotrophic bacteria in air and water and the identification of pathogens. Work here will be exploratory and will be closely coordinated with work being conducted elsewhere in EPA. There is some evidence that these bacteria are important in human respiratory disease.

Hazardous Substance Research Centers Program: In response to Congressional directives in the 1986 amendments to Superfund and EPA's 1988 appropriation act, a program was initiated in 1989 which

established five Hazardous Substance Research Centers (HSRC) around the country; their missions are to perform long-term and short-term research, as well as training and technology transfer activities to address the critical problems associated with hazardous substances.

Each center serves a pair of federal regions and concentrates its efforts on projects to address critical issues in the geographic areas served by the center. Each center is expected to have an 8-year life span and will receive approximately $1.0 million each year from EPA. In addition to its technical goals, a major responsibility of this program will be to coordinate its efforts with those of other groups performing related research.

In addition to the administrative oversight provided by ORD, each center will have two advisory committees which must meet regularly. The Science Advisory Committee (SAC), meeting twice each year, will advise the center director on directions he should take in future research, evaluate and recommend proposed projects for funding, and review ongoing research efforts. SAC membership consists of roughly one-third academically based research experts, one-third EPA laboratory and regional office representation, and one-third scientific and technical experts from other venues such as industry, states, and localities. The Training and Technology Transfer Advisory Committee, consisiting exclusively of "users," EPA regulators, regional officers, state and local officials, etc., meets annually. This group performs a similar function with respect to the training and technology transfer activities as the SAC performs for research.

The individual centers and their missions are described briefly below. Some changes in direction and emphasis can be expected after each center's advisory committees have met.

HSRC for Region-pair 1/2–Lead Institution, The New Jersey Institute of Technology: This seven-university consortium serves the highly populous and industrial states of regions 1 and 2 and benefits from being a part of the well funded and already existing New Jersey Center for Hazardous Waste Management. The institutions included in this consortium are the Massachusetts Institute of Technology, Princeton, Rutgers, Stevens Institution of Technology, Tufts University, and the University of Medicine and Dentistry of New Jersey. Although the center has a broad range of research and technology transfer responsibilities, its primary focus is on removing and treating wastes in water and groundwater.

HSRC for Region-pair 3/5–Lead Institution, The University of Michigan: The University of Michigan, in partnership with Michigan State University and Howard University, serves the hazardous substance research needs of regions 3 and 5 which include states that are experiencing some of the nation's most difficult and complex hazardous substance problems. This center has a narrow focus and is engaged in what is generally agreed to be some of the world's most sophisticated research on bioremediation techniques.

HSRC for Region-pair 4/6–Lead Institution, North Carolina State University: This is the Agency's center on waste minimization, a topic which will be of increasing importance in the years ahead. North Carolina State University, the University of North Carolina, and Texas A&M University have combined to form a unique center specializing in waste minimization and management techniques with an initial emphasis on wastes generated by the lumber industry.

HSRC for Region-pair 7/8–Lead Institution, Kansas State University: Given the diversity of concerns in regions 7 and 8, it is not surprising that this consortium consists of seven institutions from six of

the states in region-pair 7/8. The two main research thrusts of this center's program are removal and reclamation of metals, ores, and other wastes that result from mining operations and treatment and removal of organic wastes found in water, groundwater, and land. The other institutions in this consortium are Montana State University and the Universities of Iowa, Missouri, Montana, Nebraska, and Utah.

HSRC for Region-pair 9/10–Lead Institution, Stanford University: Along with Oregon State University, Stanford has established a center that will concentrate on treatment of complex mixtures and the fate and transportation of hazardous substances in the environment. Although much of the emphasis is on problems experienced by the mainland states, the center is making an effort to address the biggest concerns of Alaska, Hawaii, and Guam, as well.

Visiting Scientists Program: The Office of Exploratory Research (OER) has administered a Visiting Scientists Program since 1984. The general purpose of the program is to provide a cross-fertilization between EPA and the scientific community by attracting outside environmental scientists and engineers to the Agency on a temporary basis to collaborate in environmental research. The program has two components: a Visiting Scientists and Engineers Program and an Environmental Science and Engineering Fellows Program.

Visiting Scientists and Engineers Program: The Visiting Scientists and Engineers Program attracts eminent scientists and engineers to the Agency's research laboratories for up to three years to collaborate in environmental research efforts beneficial to both the Agency and the visitor. Selections are made annually through a competitive process. Since its inception in 1984, the program has attracted 23 such visitors to the Agency to explore a range of environmental issues and problems. At present, 11 visitors are involved in

research at the following 6 ORD laboratories: Environmental Research Laboratory, Gulf Breeze, Florida; Environmental Research Laboratory, Corvallis, Oregon; Health Effects Research Laboratory, Research Triangle Park, North Carolina; Hazardous Waste Engineering Research Laboratory, Cincinnati, Ohio; Environmental Monitoring Systems Laboratory, Las Vegas, Nevada; and Water Engineering Research Laboratory, Cincinnati, Ohio.

Environmental Science and Engineering Fellows Program: In cooperation with the American Association for the Advancement of Science, OER supports 10-week summer appointments of postdoctoral and midcareer environmental scientists and engineers to EPA facilities to conduct interdisciplinary mini-assessments of environmental problems and options. This program was initiated in 1980 as part of ORD's outreach activities directed toward identifying and evaluating long-term environmental issues. To date, 54 fellows have participated in the program.

Small Business Innovation Research Program (SBIR): The Small Business Innovation Development Act of 1982 (P.L. 97-219), an amendment to the Small Business Act, requires the EPA and certain other federal agencies to set aside a specified percentage of their extramural research and development (R&D) budgets for a SBIR Program. The primary purpose of this legislation is to (1) stimulate technological innovation; (2) use small business to meet federal research and development needs; (3) increase private sector commercialization of innovations derived from federal research and development; and (4) foster and encourage participation by minority and disadvantaged persons in technological innovation.

The EPA SBIR program solicits proposals focusing on innovative research projects that are concerned with national pollution control in solid, liquid, and gaseous

media. Research in the development of environmental instrumentation and measurement methods is also solicited, where it is directly connected to pollution control processes.

The EPA SBIR program, as is the case with all other participating agencies, is operated in three phases. In Phase I, a general solicitation is released requesting proposals to conduct a six-month feasibility study. Phase I recipients receive support of up to $50,000. Phase II research consists of a development study which can last a maximum of two years and, although Phase II projects can receive up to $500,000 in funding, due to program and resource considerations the program provides a maximum of $150,000. In Phase III, the product or process developed in Phase II is taken to a private venture company or other investor for assistance in the commercialization of the process or product. Only nonfederal funds are used in Phase III.

Up through fiscal year 1988, the SBIR program has supported approximately 115 Phase I projects. About 50% of the Phase I projects funded through 1987 has received support in Phase II.

The legislation which authorized the SBIR program (PL 97-219) is effective through September 30, 1993, and, as required by a sunset clause contained therein, the program will terminate in 1993 unless Congress acts prior to that time. Through fiscal year 1993, the SBIR program will continue to support the innovative ideas of small and disadvantaged businesses engaged in the development of processes and instrumentation for pollution abatement and control.

Quality Assurance

How does the Agency assure that its environmental data collection is of high quality?

A significant portion of EPA's budget is spent on collecting environmental data. Quality assurance (QA) activities play an integral role in the planning and implementation of environmental data collection efforts and in the evaluation of the resulting data. QA is the process of assessing whether the data provided by data collectors to line managers is of the quality needed and claimed. QA should not be confused with quality control (QC); QC includes those activities required during data collection to produce the data quality desired and to document the quality of the collected data (e.g., sample spikes and blanks).

The Quality Assurance Management Staff (QAMS) is charged with overseeing the QA activities of the Agency. QAMS came into being in May 1979, when the Agency recognized the need for formalizing an Agency-wide QA program for all environmental data collection activities. More recently, with the issuance of EPA Order 5360.1 in April 1984, the Agency's QA program has been significantly strengthened and broadened. The Order mandates that QA be an integral part of all environmental data collection activities, from planning through implementation and review.

In recent years, the Agency's QA activities have focused on identifying the basic elements that are essential to effective QA for environmental data. QAMS has put considerable effort into issuing guidance defining and analyzing these key elements. The long-range outlook for the QA program is a transition from the guidance phase to implementation. During the next several years, QAMS will support all EPA environmental data collection programs in pursuit of the following priorities: (1) creation of QA program plans for all EPA organizations with environmental data operations; (2) Agency-wide implementation of the data quality objectives process; (3) routine performance of management systems reviews and audits of data

quality; and (4) establishment/communication of common technical practices and methods.

Research to Improve Health Risk Assessment

What research efforts are needed to improve the technical quality of Agency risk assessments?

The Agency increasingly relies on quantitative assessment of health risks to make decisions about protection of public health. The utility of the risk-based approach to decisionmaking depends upon the availability of an adequate data base that is appropriate for the questions being asked. Insufficient data can lead to large uncertainties that, in turn, allow wide latitude for interpretation.

This research program is designed to provide critical data on the relationship between exposure (applied dose), dose to target tissue (delivered dose), and associated health effects. The program emphasizes laboratory and field research that will improve our understanding of basic biological mechanisms, especially as they relate to our ability to extrapolate from one set of circumstances to another.

Four general topic areas are being investigated: (1) Analysis of Uncertainty assesses the major contributors to uncertainty for a given risk assessment, (2) Integrated Exposure Assessment improves the quality and consistency of data used to assess exposure, (3) Physiologically Based Pharmacokinetic Models can be used to establish a quantitative relationship between exposure and dose delivered to a target site under a variety of conditions, and (4) Biologically Based Dose-Response Models allows for deliniation of a quantitative relationship between the dose and associated health effects.

Interagency Coordination on Environmentally Related Disease

What efforts are under way to promote interagency cooperation in the study and prevention of environmentally related disease?

The Task Force on Environmental Cancer and Heart and Lung Disease is an interagency group established by Congress to promote cooperation and coordination and to recommend research to determine and quantify the relationship between environmental factors and human disease. The Task Force was established by Section 402 of Public Law 95-95, the Clean Air Act Amendments of 1977.

The Task Force is comprised of members from the U.S. Environmental Protection Agency, the Public Health Service, the National Cancer Institute, The National Heart, Lung, and Blood Institute, the National Institute of Environmental Health Sciences, the National Institute for Occupational Safety and Health, the National Center for Health Statistics, other components of the Centers for Disease Control, the Food and Drug Administration, the Department of Energy, the Consumer Product Safety Commission, the Department of Agriculture, the Veteran's Administration, and the Agency for Toxic Substances and Disease Registry. The Department of Defense is an observer of the Task Force.

Recent activities of the Task Force have been in public education and communication, health professional education, effects of pesticides on human health, environmental epidemiology, and risk communication. Future activity will consider environmental and occupational asthma.

Environmental Status and Trends

How can the Agency reduce the uncertainty associated with ecological risk assessment and improve its ability to anticipate environmental problems?

Reports of ecosystem degradation are appearing with increasing frequency and suggest that cumulative, chronic insult from multiple pollutants is likely to be the cause. Addressing emerging problems on a case-by-case basis with the resources available is an ineffective means of getting ahead of the problems, bounding them, and guiding where research should be conducted. A fundamental limitation of the Agency's approach to dealing with emerging problems is the absence of an environmental monitoring program that generates the data necessary to improve our ability to address large-scale, complex environmental issues, verify the effectiveness of control programs, or quantify, with known certainty, changes in ecosystem condition or pollutant exposures.

In response to this need, the ORD has directed the Offices of Modeling, Monitoring Systems, and Quality Assurance (OMMSQA) and Environmental Processes and Effects Research (OEPER) to initiate an estuarine demonstration project that emphasizes monitoring and evaluation of current indicators of ecosystem health. Detailed statistical designs, indicator selection and evaluation, and characterization materials also will be developed for establishing baselines for the condition of inland aquatic and terrestrial ecosystems and exposures to pollutants.

Total Human Exposure

How can the Agency determine human exposure to environmental pollution?

The Total Human Exposure Program is a long-term, integrated research effort to provide the Agency with

the ability to determine both the range of human exposure and the major sources of exposure. For certain chemicals, the lack of adequate exposure information is "the single greatest source of uncertainty" (Science Advisory Board Report, 1986) in Agency risk assessments.

The program has four major components. The first includes studies to determine the activity patterns of the population, since recent data indicates that a major component of human exposure is due to people's activities, life-styles, and use of consumer products. A second major component of the program includes microenvironmental studies, in which concentrations of target chemicals due to certain activities or locations with elevated concentrations are measured. Direct measurement of human exposure through the Total Exposure Assessment Methodology (TEAM) studies will be carried out; in the early 1990's, a method for screening exposures near major point sources such as industrial plants or hazardous waste sites will be instituted. Finally, data from the above components of the program will be combined to develop models of human exposure that will allow extrapolation to the entire population at risk in many cases. All these components require adequate measurement methods, such as personal air quality monitors, and therefore measurement methods development is expected to be an integral part of the program, although not singled out as a separate entity. The results of the studies need to be communicated, and therefore a program to develop exposure assessment documents will be instituted in later years, following development of the basic scientific information.

Portions of this plan have been developed over more than 2 years by a 60-member Agency-wide task force, the Total Human Exposure Research Council (THERC). The Council has produced a document, *Research Needs in Human Exposure: A 5-Year Com-*

prehensive Assessment (1990-1994), which has been reviewed by the Science Advisory Board (Panel on Exposure Assessment) and has been found to be "a blueprint for Agency actions." Other portions of this plan have been developed in coordination with the plan for Research in Improving Health Risk Assessment (RIHRA). Thus, the elements of the program are the fruit of a longstanding planning effort that has been actively pursued for more than 2 years.

Activity Pattern Survey: Recent studies of exposure have shown that people's activities are crucial in explaining their exposures to a wide variety of chemicals. However, most previous studies of people's activities have been carried out by sociologists who have not asked the questions essential to predicting human exposure. Therefore, a major survey will be undertaken of people's activities, using a questionnaire that is designed and fully pretested by survey design specialists. An advisory peer-review panel will be set up to assure the scientific excellence of the approach. The subjects, to be chosen in a rigorous probability survey, will carry an automated microprocessor-driven activity logger to aid them in filling out the questionnaire accurately. The activity pattern information will be combined with information from the concurrent "microenvironmental studies" (see below).

Microenvironmental Studies: Regional, state, and federal risk assessors are in need of data on literally hundreds of exposure situations. For example, volatilization of chemicals during the household use of contaminated water has recently been recognized as a potentially important source of exposure. However, virtually no measurements have been taken in this important microenvironment. Other examples include the use of consumer products such as paints, air fresheners, and pesticides containing potentially carcinogenic chemicals, exposure to environmental tobacco

smoke in the office environment, and a host of similar situations on which virtually no measured data exist.

In many cases, the absence of data is not due to the lack of measurement methods, but simply to the lack of appropriate small-scale microenvironmental studies. Recently one such study of several of the above situations was carried out and resulted in the collection of valuable new data that offices such as OPTS; agencies such as CPSC; and risk assessors in the program offices and in regional and state agencies are now using in their risk assessments.

The studies will consist largely of direct measurement within the microenvironments, with the goal of characterizing the distribution of concentrations within the microenvironment. Ancillary information on the times spent within the microenvironment and the values of the parameters to be used in exposure models would also be collected.

TEAM Studies–Screening Exposure Around Major Point Sources: People living near major point sources, particularly smelters, landfills, hazardous waste sites, etc., are concerned about their current exposures. However, direct measurement of all the possible routes of contamination (soil, track-in, groundwater contamination, airborne particles, or toxic gases) would be excessively costly. By using the human body as an integrator of all these exposures, we can determine directly whether exposures are occurring. A single measurement of body burden (breath, blood, etc.) can determine current or recent exposure to scores of toxic compounds of interest.

The methods exist presently to determine exposures to 25 volatile organic chemicals by a single measurement of exhaled breath. The measurement lasts 5 minutes and can be carried out at home by persons of all ages, from 5 to 85.

Development and Validation of Human Exposure Models: Human exposure models require data from two different sources, activity patterns and microenvironments. Both sets of data will be obtained by the concurrent activities in this program. The existing model, which has been tested only for carbon monoxide, will be extended to cover toxic chemicals and pesticides. Modules extending its coverage to food and water intakes will also be prepared. Contributions from outdoor sources to human exposure will also be modeled in those cases where outdoor levels contribute significantly to human exposure. Since body burden is a central portion of this approach, models relating breath or blood levels to previous exposure need to be developed and validated.

A central component will be model validation. The models will be validated using field data on exposure and body burden collected in total human exposure field studies.

Summary of Long-Term Trends

The basic goal of the scientific assessment activity will continue to be ensuring Agency-wide consistency and high technical quality in risk assessments. This will be especially critical as the Agency moves increasingly toward risk-based decision making and toward decentralization of risk assessment. Development or revision of risk assessment guidelines will continue. The Risk Assessment Forum will continue to consider health risk issues but will emphasize exposure assessment issues to the extent that resources are available. The current OHEA research program to reduce uncertainties in risk assessment will continue and will be carefully integrated with other risk assessment research programs. New chemicals will be added to IRIS, existing information will be updated, and new files will be created as needed.

Technology transfer is a continuing responsibility. In response to requests from EPA program offices and the needs expressed by the regions and the states, ORD disseminates the available technology and technical data to states and localities to enable them to meet their regulatory responsibilities. Technology transfer activities will include the design, production, QC, and distribution of materials such as design manuals, user's guides, handbooks, and workshops. It also includes assessing the state-of-the-art computer delivery technologies for these materials.

The research grants and centers program goals will continue to be to:

1. Make the environmental research community aware of and active in working on problems of interest to EPA;

2. Promote close interaction and mutual awareness between EPA researchers and the environmental research community; and

3. Provide support to the research community for work on fundamental environmental research, thereby promoting a solid foundation of knowledge and a cadre of scientific and technical personnel in the environmental sciences.

During the next several years, QAMS will support all EPA environmental data collection programs in pursuit of the following priorities: (1) QA program plans; (2) data quality objectives; (3) management systems audits and audits of data quality; (4) documentation of routinely used measurement methods; and (5) QA outreach and training.

III. APPENDIX

Interagency Coordination

Reorganization Plan 3, which established the EPA, did not intend that all relevant environmental research be included within the EPA in-house research establishment. The Agency was expected to rely in part on relevant research and development performed by other federal agencies as well as non-federal organizations.[1] Acquiring and integrating such information was considered to be an important function of the EPA R&D operation.

A review of the recent Directory of Federal Laboratory and Technology Resources[1] indicates the breadth of environmentally related research and development being done in the non-EPA federal laboratories. In order to prevent unnecessary duplication of research efforts, awareness of such activities and available information is considered in the development of the EPA research program.

In addition, interagency cooperation and coordination is utilized to bring the appropriate expertise to bear on environmental problems. Interagency committees and interagency agreements are techniques utilized to effect the communication and coordination.

The Office of Research and Development presently has active interagency agreements with the following agencies:*

- Department of Agriculture (measurements, ecology, transport and fate, health, engineering)

---

[1] Directory of Federal Laboratory and Technology Resources, 1986-1987, PB86 100013, Center for Utilization of Federal Technology, U.S. Department of Commerce, NTIS, 1986.

* Disciplines and/or areas of cooperative agreement are inserted parenthetically.

- Department of Defense (measurements, engineering)
  - Army (measurements, ecology, health, engineering)
  - Army Corps of Engineers (engineering, measurements, ecology)
  - Navy (engineering, measurements, transport and fate)
  - Air Force (engineering, measurements, ecology, transport and fate, health)
- Department of Commerce (measurements, ecology, health, engineering)
  - National Bureau of Standards (measurements)
  - NOAA (transport and fate, ecology)
- Department of Energy (engineering, assessment, measurements, ecology)
- Executive Office of the President (measurements, exploratory research)
- Department of Health and Human Services (ecology, health, engineering)
  - Food and Drug Administration
  - National Institutes of Health
- National Aeronautics and Space Administration (health, ecology)
- Department of the Interior (measurement, ecology)
  - Geological Survey (training, technical assistance, transport and fate, monitoring)
  - Fish and Wildlife Service (ecology)
- National Science Foundation (exploratory)

- Tennessee Valley Authority (ecology, measurement)
- Department of Transportation (engineering)

Examples of the interagency committees on which EPA/ORD is represented include the following:

- Interagency Committee for Stratospheric Ozone Protection
- Task Force on Environmental Cancer and Heart and Lung Disease
- Interagency Committee on Indoor Air Quality
- National Ocean Pollution Policy Board
- National Acid Deposition Assessment Program
- Biotechnology Science Coordinating Committee
- Interagency Advisory Committee on Water Data

SCIENCE ADVISORY BOARD LETTER

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

EPA-SAB-EC-89-022

June 15, 1989

OFFICE OF
THE ADMINISTRATOR

Honorable William K. Reilly
Administrator
U. S. Environmental Protection Agency
Washington, D. C. 20460

Dear Mr. ~~Reilly~~ Bill:

The Science Advisory Board has conducted a series of scientific reviews of Agency research programs that have proven to be a highly useful means of assessing the quality and relevance of existing research, identifying research needs and involving the scientific community in the research planning process. Such reviews have also aided internal communication within the Office of Research and Development (ORD) and between ORD and the program offices.

In FY 1988 the Science Advisory Board issued a comprehensive report on the future directions of research at EPA entitled, Future Risk: Research Strategies for the 1990s. Former Administrator Lee Thomas agressively pursued most of the recommendations in the report. Also, at his request, the SAB has established a new standing committee, the Research Strategies Advisory Committee, which provides continuing oversight of the implementation of those recommendations. With the support you have already shown for such activities, this promises to be a most effective way of monitoring and encouraging the research program at the Agency.

In addition to Future Risk, the SAB and its committees released reports on research in a number of specific areas, including land disposal, drinking water disinfection and disinfection byproducts, radon mitigation, biotechnology risk assessment, drinking water distribution systems, waste minimization, municipal waste combustion, non-ionizing radiation, and extrapolation modeling. Finally, Board members also reviewed over 100 papers published by EPA scientists to identify those of sufficient quality and importance to qualify for EPA's Scientific and Technological Achievement Award.

Based upon similar activities conducted during FY 1989, a comparable number of reports on Agency research will be issued this year.

The purpose of presenting this information is to inform you that such activities have focused both the SAB's and the Agency's thinking on research plans and needs to a degree never before achieved through preparation and review of the Five Year Research and Development Plan (Research Outlook). As you know, Congress has required that the Agency provide the SAB with the opportunity to review the plan. The Board believes that its extensive research program reviews fulfill the spirit and intent of Congress for SAB oversight of the Agency's program. Comments on specific issues in the five year plan have also been addressed in individual research program reviews.

The Board reiterates its long-standing support of research addressing problems beyond the immediate regulatory needs of the Agency.

Sincerely,

Raymond C. Loehr
Chairman, Executive Committee
Science Advisory Board